MARINE GASOLINE ENGINES

A PRACTICAL TREATISE

MARINE

GASOLINE ENGINES AND EQUIPMENT

An Exhaustive, Scientific Treatise on Correct Design, Construction, Installation and Operation of Power Boats.

for

BUILDERS
YACHTMEN
FISHERMEN

Including MARINE ENGINE METHODS generally and "FERRO" METHODS in detail

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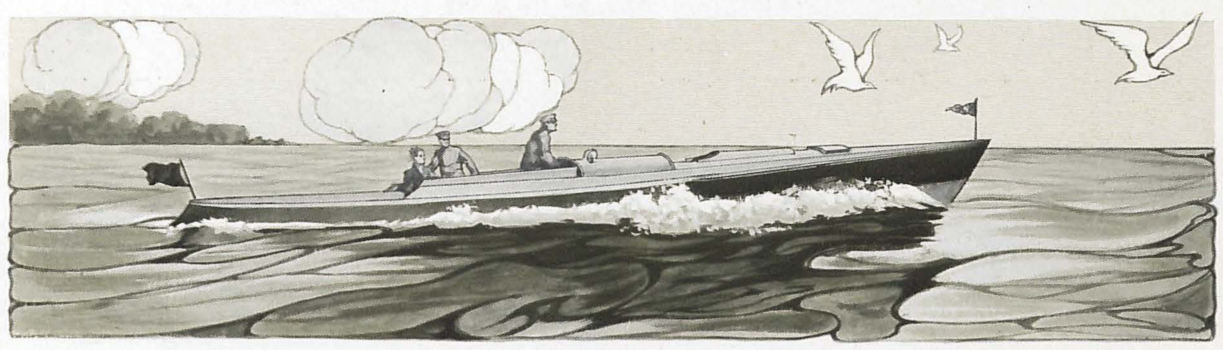


INTRODUCTORY

THIS Treatise is a simple, non-technical book covering the design, construction, installation and operation of marine motors. It is intended, primarily, for the man who is not a mechanic. Fully 80 per cent. of the engines built by the Ferro Machine & Foundry Company are used by people who have little or no "motor knowledge." Other makers of marine motors also sell to the inexperienced. The Ferro Machine & Foundry Company recognize the fact that few people have an opportunity to operate a motor before they own one. Their organization has seen, from its inception, the necessity of prosecuting a campaign of education. The layman must know his motor if he would get pleasure and service from his power boat. He must have a "working knowledge" at least, and if he understands the details of motor construction and operation, so much the better.

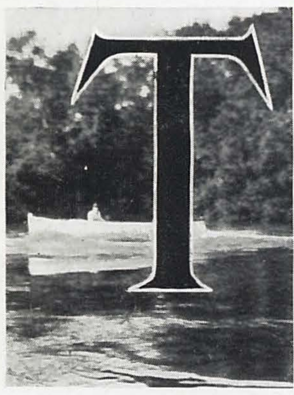
The successful use of motor boats and the growth of the engine and boat business depend largely on the character and scope of this educational work. Thousands of present and prospective owners must be taught how to use their engines. The size of the task is enough to discourage even the largest organization.

The Ferro Machine & Foundry Company has never shirked the burden of this campaign. The first edition of the Treatise issued in 1907 had for its key note "Know Your Motor." A larger work was prepared at great expense and circulated widely in 1908. This still larger edition for 1909 is a greater effort to make owners understand the construction and operation of their motors.

Much of the material in this edition is new. The engine and boat experts who have collaborated in its preparation have brought the various subjects up to date and treated them to such length as space would permit.

The Ferro Machine & Foundry Company is more favorably situated to publish an extensive work of this kind than any other manufacturer. They operate a modern pattern shop, a large foundry and extensive machine shops. They employ the largest staff of specialists in all departments and under one management. The size and reputation of the concern attracts and holds the best workmen. Consequently this Treatise does not exploit the "hobbies" or "pet theories" of any one man. It describes facts and principles which are recognized and accepted after years of experience. These are embodied in the Ferro motors which illustrate the text. The same principles hold good, however, in any good engine of similar type.

The Actual Working of Marine Gasoline Engines



THE ordinary gasoline motor consists of a stationary member *C* called the cylinder and movable members *P*, *R*, *S* and *W*, namely the piston, the connecting rod, the crank shaft and the fly wheel. Fig. 1 represents a Ferro Marine Motor cut in half vertically and one-half removed, leaving the working parts in full view. In order to start this motor, it is necessary to turn the fly wheel over by hand a certain distance. When this fly wheel turns, the shaft *S* also turns because the fly wheel is attached to it and revolves on the same center. Attached to this shaft, or in fact, a part of it, is the crank arm *A* to which the connecting rod *R* is attached by means of a pin *P*. When the shaft *S* revolves, the crank arm *A* being part of it, moves with it and pushes or pulls the connecting rod *R* up or down according to the direction of rotation of the shaft *S*. In turn the connecting rod pushes the piston *P* up or down before it. In fact, the functions of the connecting rod *R* to the gasoline engine are the same as those of the connecting rod to the steam engine. It is the bridge, one might say, between the source of power and its application.

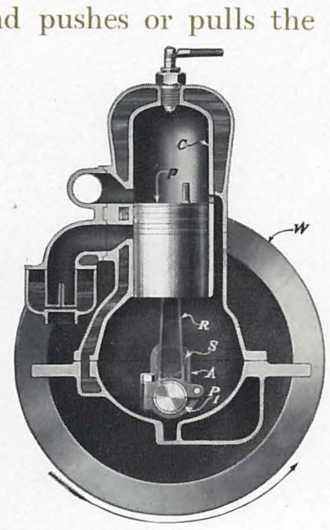


Fig. 1.

Now we will assume that we have just received this motor from the factory and have it set up ready for running with all connections made. Turn on the gasoline, then take the starting crank and turn the fly wheel slowly in the direction indicated by the arrow. You will notice that in Fig 2, the piston *P* has ascended and in Fig. 3, it has traveled upward still farther. The very fact that this piston is moving away from the crank-case, thereby increasing its volume without allowing any air to enter up to a certain point, causes a vacuum and the first opportunity the outside air gets to rush in and destroy this vacuum, it will do so. By examining the first three figures, you will notice that the piston has been ascending, and in Fig. 3 it has uncovered the inlet *I* thus allowing the outside air, which has passed over a jet of gasoline on its way in, to enter the crank-case. You will also notice that the fly wheel has now been turned a half revolution. Now let us continue turning the fly wheel in the same direction and notice that the piston is descending. Again it cuts off the opening *I*, squeezes the gasoline vapor in the crank case and opens the inlet I_2, to allow the compressed vapor of the crank-case to enter the cylinder above the piston, Fig. 4. This gas or

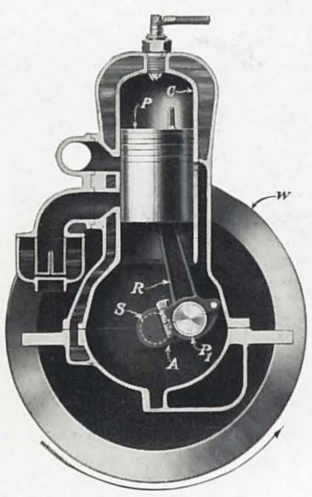


Fig. 2.

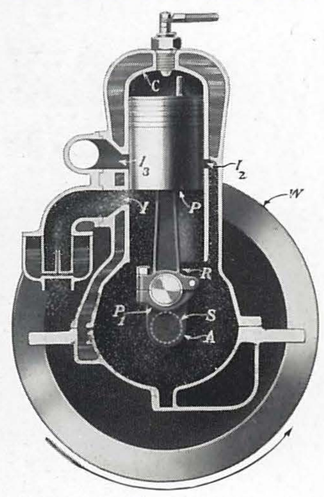


Fig. 3.

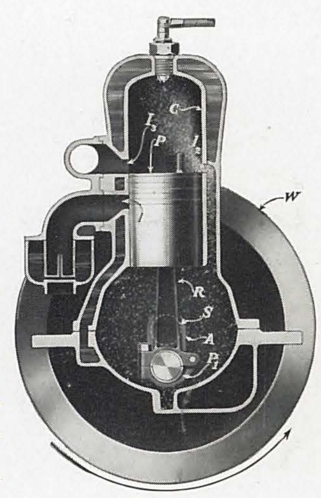


Fig. 4

vapor is very explosive under compression and will, by the application of heat, expand rapidly and has the power of doing work. In order that the motor will run by itself, the fly wheel must be turned another half revolution, thus bringing the piston up again and compressing the gas above the piston as shown in Fig. 5. Just before the piston starts to descend again, the compressed gas above it is ignited by an electric spark which is governed by the sparking mechanism, the details of which we will not enter into here. This electric spark ignites the vapor causing it to suddenly expand and push the piston downward before it. These hot gases are allowed to escape into the atmosphere through the opening I_3, Fig. 6, which is also governed by the piston. When these hot gases have escaped to the atmosphere, a fresh charge of gas is allowed to enter the cylinder through passage I_2, and is kept from escaping through the exhaust opening I_3, by the baffle plate.

Notice, that while it required a turn and a half to cause an explosion at the beginning, because the initial charge had to be drawn into the cylinder, it requires only one revolution or two strokes of the piston to cause an explosion after the engine is running under its own power. By reason of this motor receiving an impulse or explosion above the piston every two strokes of the piston, which constitute one revolution of the fly wheel, the motor is termed a two-cycle motor to differentiate it from a four-cycle motor which receives an impulse every two revolutions of the fly wheel or every four strokes of the piston.

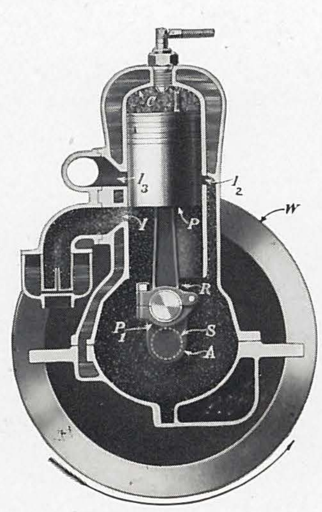


Fig. 5

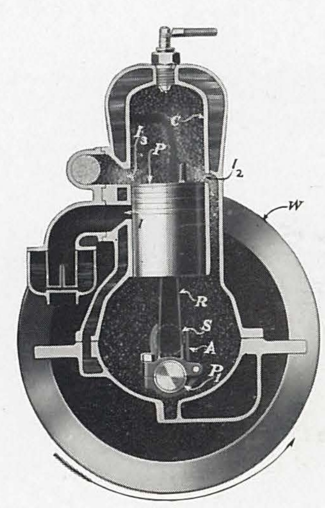
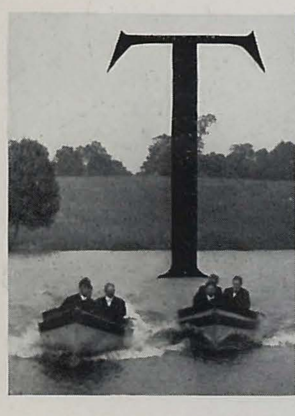


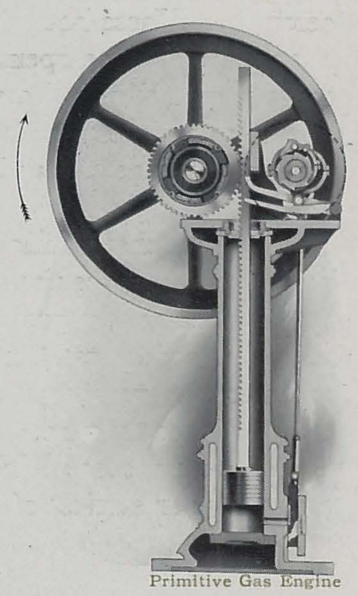
Fig. 6

Historical Review



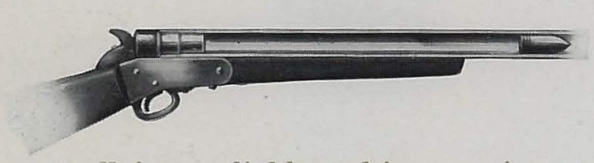
THE year 1680 witnessed the first permanent step in the direction of the development of power from combustion. Hyghens, an early inventor conceived the idea of confining a combustible in a closed chamber with a movable end and firing this combustible by the application of heat, causing it to expand, pushing the movable end outward, thus performing work.

The power producing element thus used by Hyghens was ordinary gun powder. The action of his motor may be paralleled to that of a modern fire-arm, the barrel of the gun composing the closed chamber, the bullet, the movable end and the powder, the power producing element. When the hammer falls the powder in the cartridge is ignited thus causing it to explode and force the bullet from the barrel.



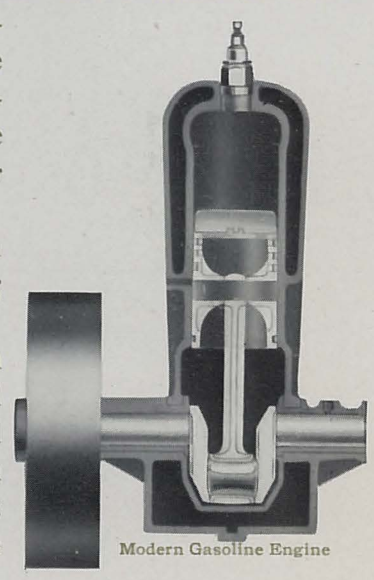
Primitive Gas Engine

In a similar way the modern gasoline engine employs the use of ordinary gasoline vapor as the power producing element. A cast iron receptacle called a cylinder confines this vapor, and a movable end, called a piston, snugly fits into this cylinder. In the fire-arm analogy we see that the bullet is allowed to go free into space and for every successive charge, of course, a new bullet must be used. In the gasoline engine this is not the case. The same piston is used until, by reason of wear or friction, it is discarded. Instead of its leaving the cylinder entirely as does a bullet, its travel is confined to certain limits and it is brought back again after each successive charge to its initial position. Thus the piston travels back and forth in its path within the cylinder and the successive explosions are controlled automatically. As gasoline is one of the most efficient, reliable and inexpensive sources of power, manufacturers of internal combustion motors throughout the world have devoted their close attention to its use as a power producing element.



Gasoline is a distillate obtained from crude petroleum and is highly volatile. It evaporates rapidly upon coming into contact with the atmosphere.

The very fact that gasoline is highly volatile is taken advantage of in the design of gasoline motors. The liquid gasoline is not drawn directly into the cylinder but is vaporized first by bringing it into contact with air. The air is drawn over the surface of the gasoline thereby evaporating a part of it and this, combining with the vapor, makes an explosive

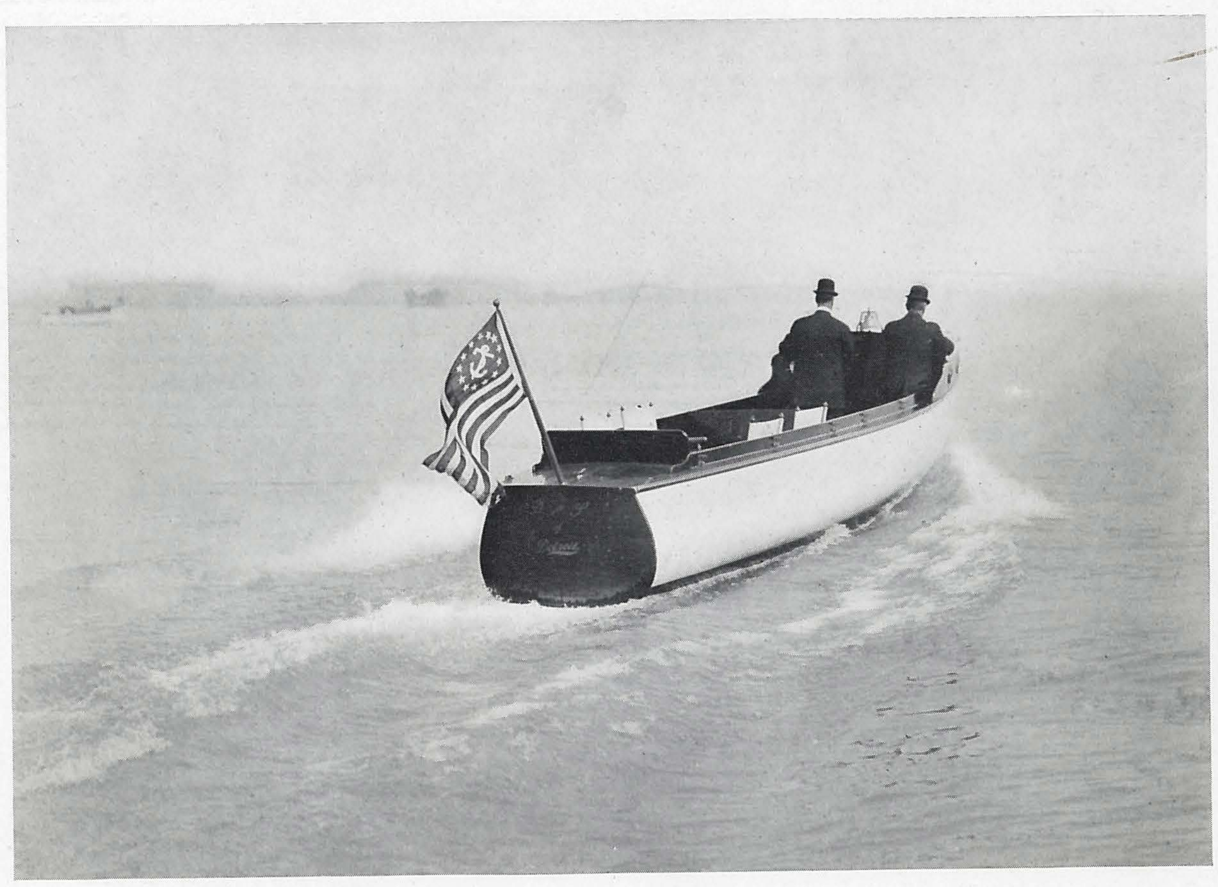


Modern Gasoline Engine

mixture. This mixture is then drawn into the cylinder, all openings are closed and an electric spark or some other source of heat is used to explode the charge, thereby exerting power in all directions. Necessarily the cylinder and piston are made of cast iron in order to withstand the tremendous pressure and heat produced by the explosion of the gaseous vapor within.

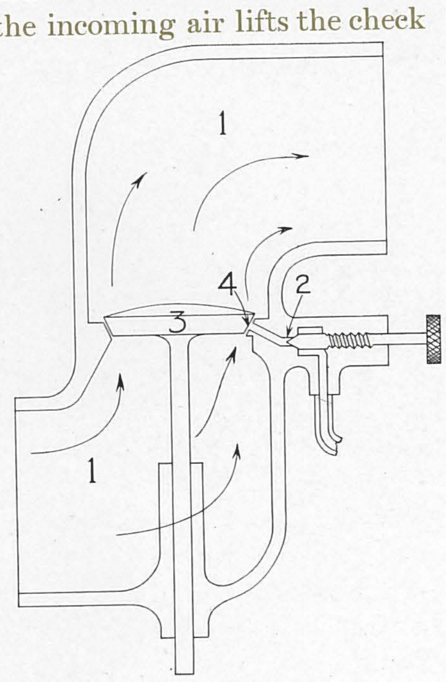

Modern Motor Cylinder

Thus we see that in the gasoline motor we must provide some means of vaporizing the gasoline, then lead it into the cylinder, later firing it. In the steps of this process other elements arise in opposition which must be cared for or else they would soon overcome and destroy the conditions for successful operation. These are: 1st, the amount of heat generated by the explosion of the gas; 2nd, the friction created by the moving parts. Hence from the foregoing we may see the necessity of vaporization, ignition, cooling and lubricating systems.



The Carburetor

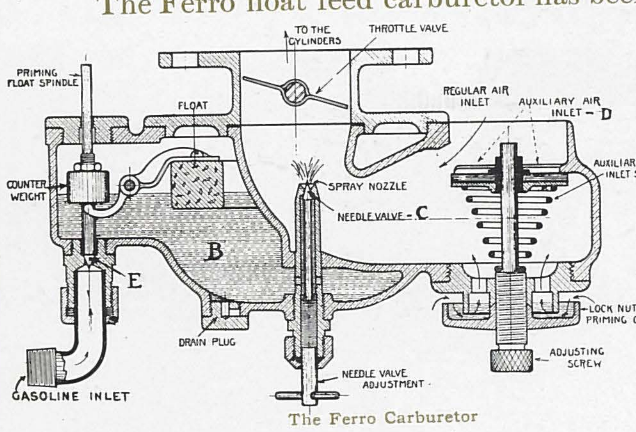
THE original method of mixing gasoline vapor and air in proper proportions for combustion was with a mixing valve, generator or vaporizer, as they are commonly called. This consists chiefly of an air chamber (1), or passage in which a needle valve (2), is situated. This valve is practically the same as the needle valve on the common gasoline stove in that it sprays the gasoline into the burner. The burner in this illustration would represent the mixing chamber. In connection with this passage or mixing chamber with its gasoline valve is a check or disc valve (3), which operates in holding the vaporous gases in the motor as they pass from mixer. At every up stroke of the engine piston, with the two cycle motor, the partial vacuum or suction in the crank case causes an influx of air through the mixing valve. The force of the incoming air lifts the check valve (3). This valve when it lifts, uncovers the small gasoline port (4), allowing it to spray the liquid into the air chamber (1), and become mixed with the inrushing air. When the engine piston starts downward compressing the charge in the base, as better described on page 4, the check valve (3) closes, holding the charge and also closing the gasoline port until the next similar operation.



Mixing Valve

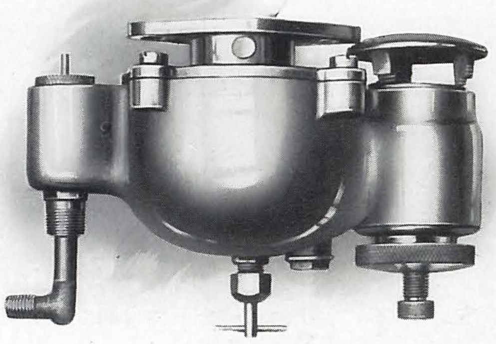
This type of generator works very successfully but lacks the feature of a steady constant feed of gasoline where the gravity flow varies, as it does with a full or nearly empty gasoline tank. Again the varying speeds of the motor will affect the feed of gasoline into the mixing chamber. In both these cases it requires an adjustment of the needle valve (2), by the operator. It is hardly necessary to state that this feature of constant care with the generator valve is a worry and nuisance to the operator under conditions above mentioned.

The Ferro float feed carburetor has been designed to maintain a steady feed of gasoline under all varying conditions. The operation of the carburetor is principally like the generator in spraying the gasoline, except that the gasoline is fed into the chamber (B), where its level is held constant so that the gasoline just sprays at the needle valve (C). This constant level of the fuel is automatically controlled by a cork float, which you will see mechanically controls another needle valve or float valve (E).



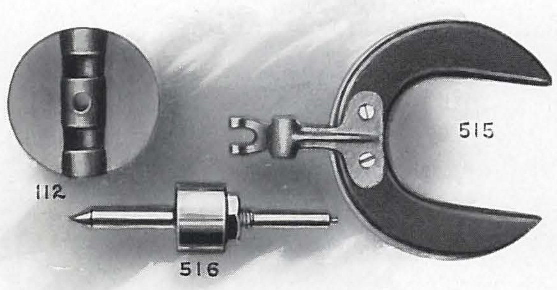
The Ferro Carburetor

When the gasoline level rises, the cork float rises, closing the float valve (E). On the contrary, when the level lowers so does the cork float, thus opening the float valve (E). The center of gasoline level in the float chamber (B), is at the spray valve (C), so that the carburetor when tilted to any slight angle in its upright position does not affect the steady feed of the gasoline.



Carburetor

To adjust more delicately the mixture of gasoline vapor and air automatically, a light disc (D), resting on a soft spring is placed in the air intake. It acts as a cushion on the inrushing air and hence serves to control the quantity of air entering the carburetor. At slow speed of the motor it remains practically inactive, automatically reducing the volume of gasoline mixture as well as changing the consistency of the mixture to the proper proportion, which is necessary for the best combustion at slow speed. On the other hand, when the motor is running at high speed, this disc valve opens, its automatic action increasing the volume of mixture, also altering it to proper consistency for best combustion at high speed.

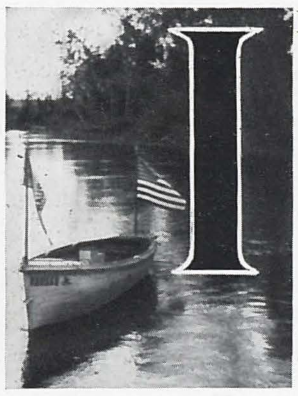


112 Throttle 516 Float Valve 515 Cork Float

Another disc, a butterfly valve, operated by a hand lever, serves as a throttle to control the volume of vaporous gases entering the motor. The priming stem serves to open the float valve by hand, independent of the automatic float device.

In the above description we have used the standard Ferro carburetor for illustration, as it serves to give the reader the developments of the latest improved type.

Ignition



IN order to explode the charge of vaporous gases that are drawn into the cylinder, some means must be provided for supplying heat in the proper amount and at the proper time. This heat may be furnished by various methods, namely, the hot tube, the incandescent filament, a heated surface or an electric spark. The hot tube method consists essentially of heating a hollow porcelain or metallic tube to incandescence, and bringing the gases into direct contact with this surface, Fig. 1. The incandescent filament method consists of heating a loop of platinum wire to incandescence by passing an electric current through the wire, and bringing the gases into contact with it, Fig. 2. The heated surface method, Fig 3, is similar to that of the hot tube. The only essential difference lies in the fact that the hot tube is kept heated by means of a gas flame applied from the outside and which is kept burning throughout the whole time the engine is running. With the heated surface method the gas flame is used at the outset to bring the surface to a red heat and is then extinguished when the engine is under way. This surface absorbs the heat developed by the explosions and compression which maintain its necessary temperature. With the electric spark, Fig. 4, the method consists of sending an electric current to a spark coil where it is transformed and sent on to the spark plug in the top of the cylinder, terminating in two points of the plug which are separated about one thirty-second of an inch from each other. At the proper time the current is sent through these wires causing a spark in the cylinder at the spark plug. This method is in universal use today and the advantages presented by it have been recognized by modern manufacturers; hence its universal application. Its advantages over the old time system of the hot tube, the heated surface and the filament, lie in the fact that it is simple, more reliable and easily controlled.

There are two distinct kinds of electric current in use today, namely, the high tension or jump spark and the low tension or make and break spark. Briefly, the high tension system consists of leading an electric current from dry or wet batteries, magneto or dynamo to a transformer or spark coil, thence to the spark plug, Fig. 5, which is usually located on the top of the cylinder. In order to control this spark, that is, to make the spark occur at just the proper moment, the current is thrown on and off by the use of a sparking device or timer, (see page 14), located outside the cylinder. When the

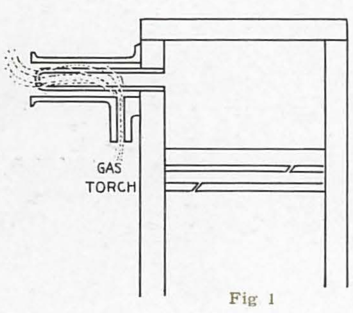


Fig 1

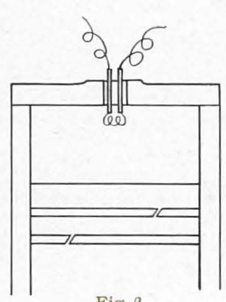


Fig. 2

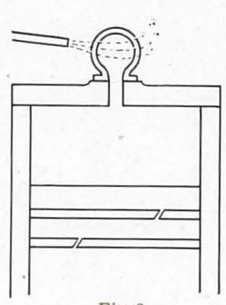


Fig. 3

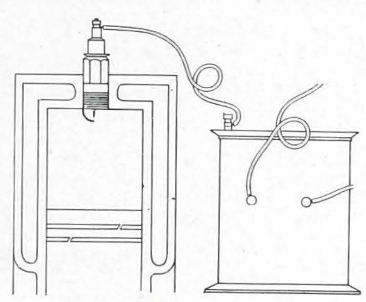


Fig. 4

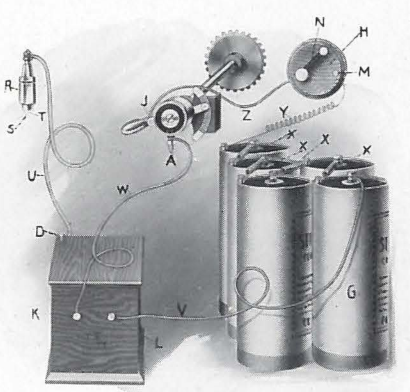


Fig. 5

current is thrown on, a spark jumps across the gap at the spark plug S-T inside the cylinder, thus igniting the charge.

A low tension system consists chiefly of leading an electric current to a coil whose functions are not the same as the coil used in the jump spark system. See page 16. From this coil the current is led to two movable contact pieces inside the cylinder. (Fig. 6.) These contact pieces are operated from without in such a manner that they come together and separate at just the proper moment to make a spark and ignite the charge.

The electric current used in producing the spark is usually drawn from one of three sources: 1, a dry cell; 2, the storage battery; 3, the magneto or dynamo.

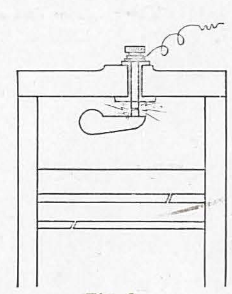


Fig. 6

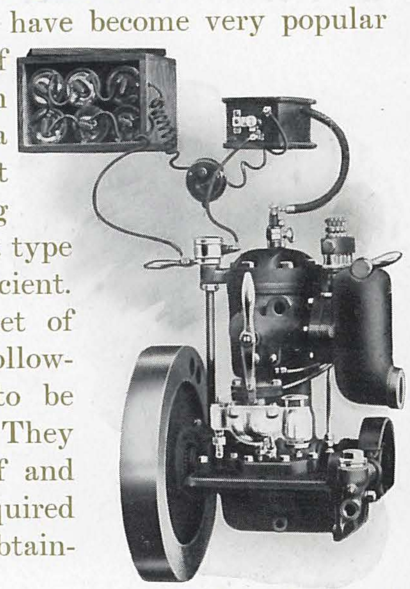
Dry Cell

The dry cell (group Fig. 5) consists usually of a carbon and zinc element immersed in moistened salts. By chemical action this combination has the power of delivering an electric current. Since the gasoline engine has come into prominence and the demand for an efficient, reliable and inexpensive source of current supply has been developed, the dry cell has been brought to a commercial degree of perfection. It is clean, not very heavy and occupies a small amount of space. A set of dry cells is regularly supplied with every Ferro outfit and before shipping, each cell is coated with a heavy sheath of paraffine or grouped in a box and entirely submerged in insulating composition, thus reducing the liability of short circuiting from moisture to a minimum. If properly installed, the dry cell will last a long time and any one cell may be removed from the set if defective and replaced by a new one.

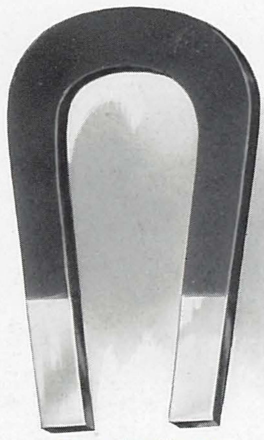
Wet Battery

Wet Batteries

Wet Batteries have become very popular for some classes of marine ignition work. There are a great many different companies supplying batteries of the wet type that are very efficient. In purchasing a set of wet batteries the following points ought to be remembered: They should be slop-proof and all renewals required should be easily obtainable.



Dry Battery Equipment for Jump Spark Ignition


Horse Shoe Magnet

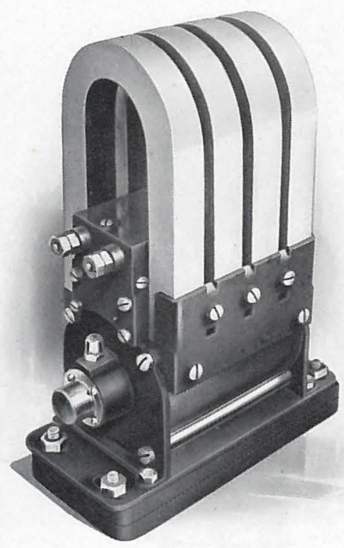
The jars ought to be as substantial as possible and constructed so that chemicals will not "creep" over the edge of the jar or evaporate.

When space allows and first cost is not of utmost importance, these batteries give excellent service when used for either system of ignition.

The advantage of this type of batteries is that the current is practically constant and the elements usually zinc and copper oxide; the liquid solution may be renewed, so that it is not necessary to buy a new set of batteries when these wet cells have become exhausted.

Magneto

A magneto is a machine for generating an electric current by employing the use of permanent electric magnets. No doubt all of us have seen the ordinary horse shoe magnet, used in picking up needles, etc. This same sort of magnet is used in the construction of the modern magneto. (See illustration) The shaft is wound with copper wire. When this shaft, called an armature, is revolved, the wire rotating between the ends of the magneto is influenced by them and an electric current is set up in the wire. This current can then be led to the spark coil and become transformed in the same manner as that of battery current. Every year finds the use of the magneto increasing.


Magneto

There is now such a variety of these machines on the market that if care is taken in the selection of the apparatus and proper installation, such an equipment will give perfect satisfaction.

The electrical requirements of the jump spark and make and break systems are not the same, so that it is necessary to construct and install magnetos adapted to these different ignition systems somewhat differently. The best magnetos for either make and break or jump spark systems, however, have been developed to a point of perfect service.


Storage Battery

The Dynamo and Storage Battery for Ignition and Lighting

The Storage Battery System consists of a dynamo and storage battery used in connection with any standard electric ignition. It can also be used to supply electricity for a number of low voltage incandescent lamps for lighting the launch. Fig. 7.

The storage battery may be used singly or in series of several numbers depending upon the capacity or dura-

tion of current required to operate a system without re-charging. The dynamo furnishes the electricity to the batteries and from them it is fed to the ignition and lighting systems. The dynamo is usually belted to the fly wheel of the motor but can be driven with a friction wheel or spur gears. Automatic speed governor is generally furnished with the dynamo and serves to maintain a steady volume of current to the battery. An automatic switch also serves to break the dynamo circuit when the batteries have been charged to their full capacity.

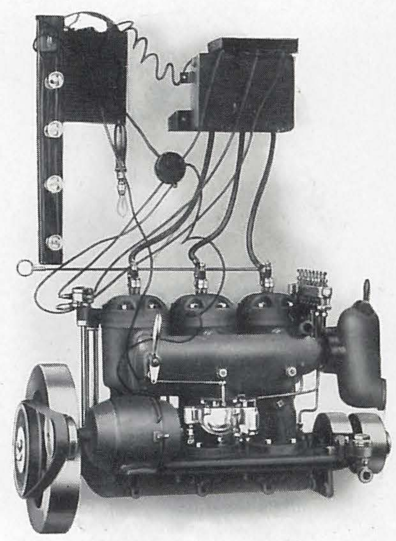
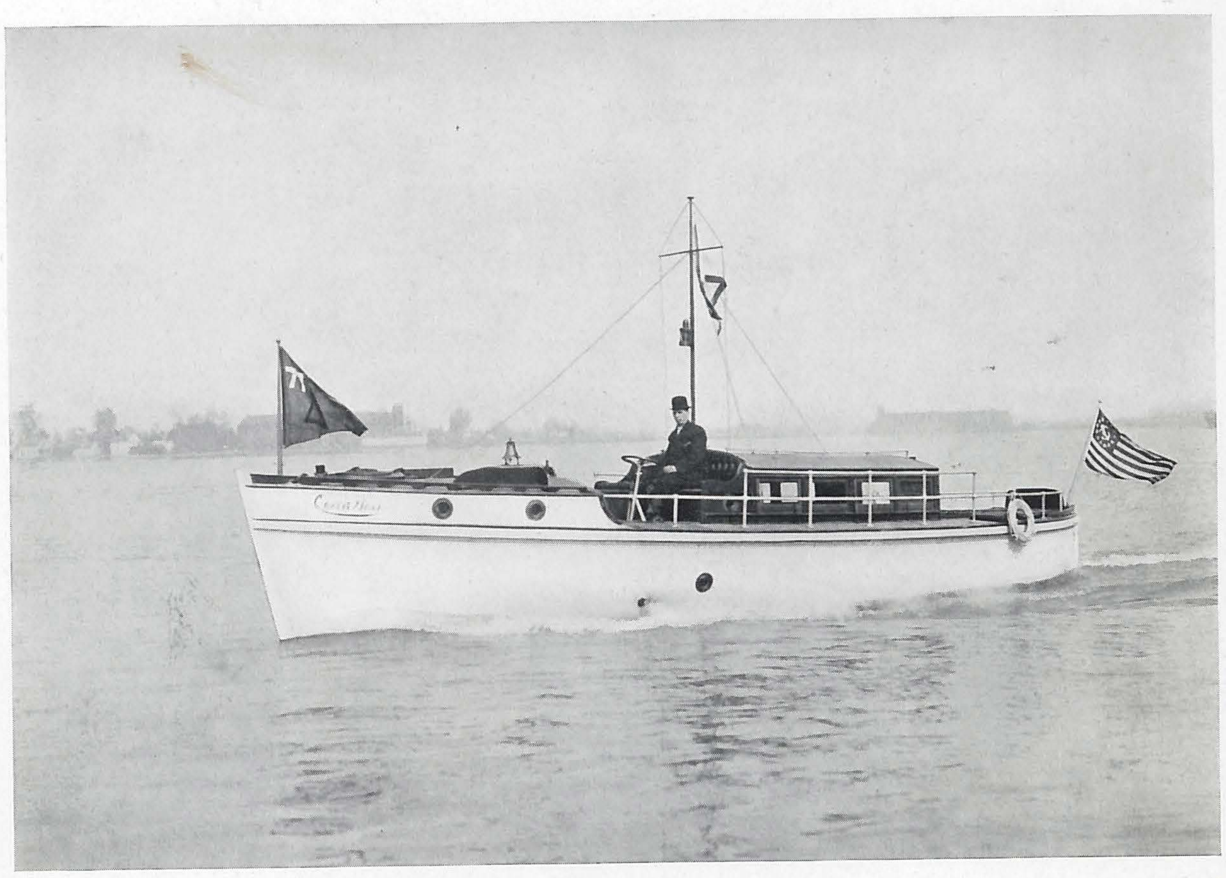


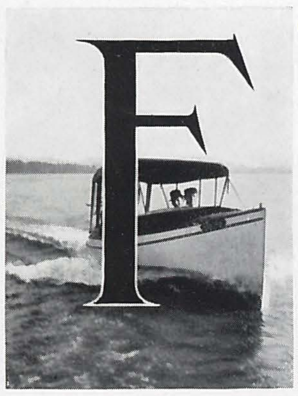
Fig. 7. Ignition and Lighting Outfit with Dynamo and Storage Battery

This system furnishes a constant and steady current and obviates the necessity of replacement or renewals as is the case with dry and wet batteries.

It is hardly possible to depend upon the dynamo alone without any batteries to start a motor, unless the speed of the dynamo can be made high enough by cranking the motor to furnish sufficient strength of electricity for ignition. Therefore it is advisable to use some source of current other than the dynamo to start the motor.



The Timer (or Commutator) for Jump Spark Ignition



FORMERLY the engine maker's attention was so much taken up in improving the main elements of the engine in order to produce high efficiency, that the timer has been neglected. Few builders of marine gasoline engines have anyone on their staffs with a practical knowledge of electricity, and only in the largest automobile plants are men available who understand both electricity and gasoline engines. The timer is a mechanical device for controlling the time for ignition of the gas in the cylinder. The one shown in Figs. 1, 2 and 3 combines the application of both electrical and engine experts. At eight hundred revolutions, the timer in a three-cylinder two-stroke engine is called upon to make 2400 perfect electrical contacts per minute, or one perfect contact every $\frac{1}{40}$ of a second, consequently it is necessary to provide a segment long enough (at least thirty-five degrees) to care for the rapid movement. The timer shown in Fig. 2 was tested up to 1800 revolutions, 5400 contacts per minute, without missing. It has an adjustment of ninety degrees, and gives economy of battery power. Referring to Fig. 3, 1 is the bronze cylindrical contact spool; 2, fibre insulation and 3, contact segment. The cylindrical contact ring slips over end of steel timer drive shaft 4, which is hollow at upper end, and slotted as shown at 5. The taper screw 6, when screwed in, expands the slotted shank, securely holding the spool.

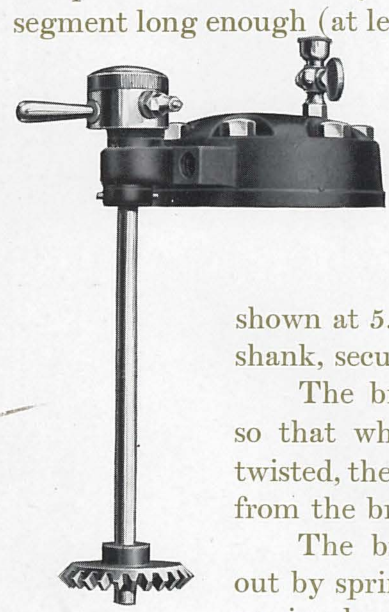


Fig. 1

The brushes 12, and attachments 20, with holes 11, are arranged so that when the connecting wires are pushed through and simply twisted, they are gripped with firm electrical contact, and are insulated from the bronze box or body 7, with hand lever 8, box nuts 10.

The brushes, 12, are simply round pieces of bronze rods pushed out by springs, 13, to make firm contact with contact spool when all are in place.

The bracket, Fig. 1, cast intregal with cylinder head, contains a ratchet quadrant, and serves also as an upper bearing in which timer shaft rotates. The collar, 18, and bronze thrust washer, 19, are set up against lower side of bracket, as in assembled views, Fig. 1. The projecting lower end of timer drive shaft rests in the bronze bearing cap on the forward main bearing. The timer is driven by its bronze gear, 23, meshing with a similar gear on the fly wheel. The circuit relief button is in a convenient position for stopping the engine instantly, by simply pressing with thumb while hand grasps timer lever, 8. A tight bronze cover, 21, closes the contact box. The timer spool and contact box are occasionally cleaned

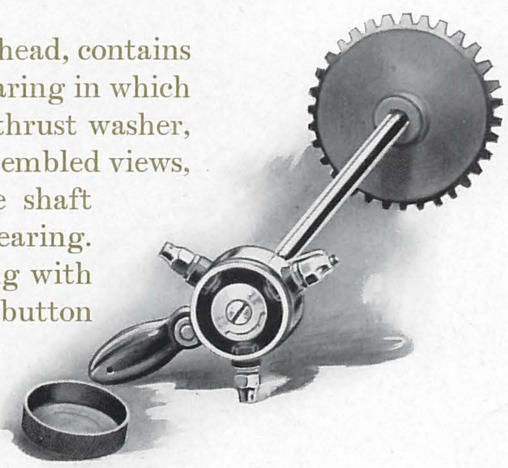


Fig. 2

with gasoline and a daub of vaseline oil spread on the spool for lubricating it. The perfect simplicity of the timer device is apparent, for it is only necessary to unscrew the taper screw 6, less than one half a turn to instantly remove all wearing parts. Spool, 1, can be reversed when worn and then replaced, or it can be turned down smooth. This can be done several times before requiring removal.

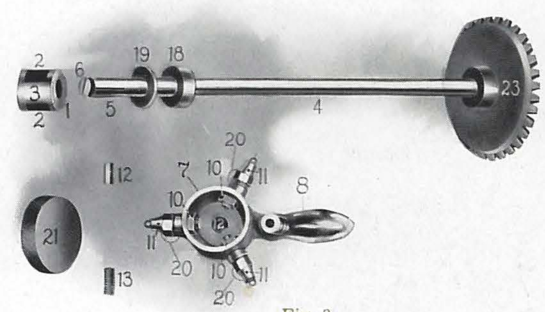


Fig. 3

Make and Break Ignition

THE make and break or mechanical ignition is the original device that was used with the marine gasoline motor. Although the jump spark device has very largely replaced the mechanical ignition, still the old method has several features of advantage over the jump spark, which make it most commendable for the commonly used open launch, such as the utility boat or fishermen's craft. The make and break ignitor by virtue of its low tension electric current, which is supplied direct from batteries or a dynamo to the sparking device, is not subject to short circuit or leakage of electricity, as is the possibility with the jump spark, due to its transformed high voltage current, where the latter is poorly installed. The damaging elements of water, moisture and even salt air, that affect the unprotected jump spark system, have no detrimental action on the unprotected make and break system, where, with the motor it is exposed to weather, spray and moisture.

It is a universally recognized fact that the jump spark ignitor is a more efficient one than the make and break, under the conditions already mentioned, but where the jump spark is not adapted and the right care and precaution are not given to the installation and operation of it, then its features of efficiency must give way to something better and more reliable, namely the mechanical spark.

One of the advantages presented with the jump spark ignition is its flexibility in timing the spark. The seeming difficulties in developing this feature with the Ferro timing device have been overcome in that an early or late spark is controlled by a lever in operating the motor either left or right hand direction.

Thus it is we advocate the make and break ignition where it is to be placed in an open boat, unprotected, and also where it is more desirable to the operator to be confronted with simple mechanical adjustments rather than a more complex electrical adjustment of the jump spark equipment.

To meet the demand of the trade in many localities where the mechanical spark is preferred, the Ferro Engineering Department has worked out several types of ignition design, conducting exhaustive tests with each, to the end that it has now a simple mechanical device, light in construction, but warranted in its durability and efficient results. The details of this ignitor the reader will find illustrated and briefly described in the following paragraphs.

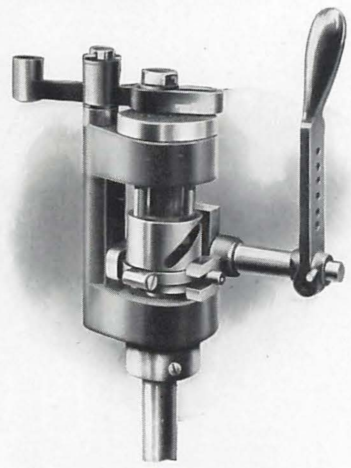


Fig. 4

The spark is generated in the cylinder at the same location as with the jump spark, and is the result of breaking an electric circuit at the points or electrodes indicated by A and B in figure 5.

The mechanism consists of the sparking device set in a brass bushing, Fig. 5. The sparking points A and B are operated by the trip rod, letter T, Fig. 6. Fig. 4 illustrates the timing device with its lever which is so constructed to advance or retard the action of the trip rod and hence gives a late or early spark.

The merit of the Ferro mechanical spark lies in the fact that it is extremely simple, consisting of the least number of working parts. Its mechanical action is short and consequently capable of high speed with the motor and accompanying accuracy in the time of required ignition. All the movable parts are constructed of case-hardened steel, offering the greatest strength and durability. The electrode points are of nickel steel, free from any tendency of rusting and always maintaining a clean electrical contact.

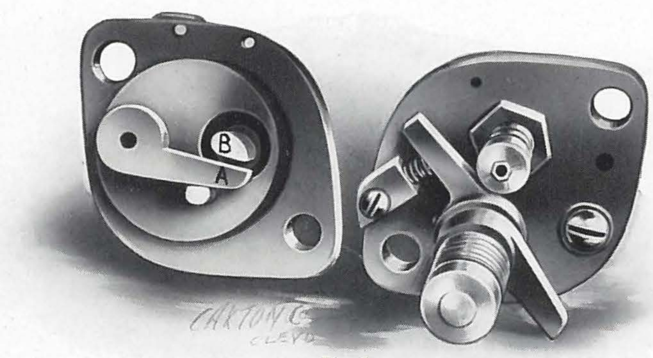


Fig. 5

The Ferro mechanical ignition is designed to allow right or left hand operation of the motor, with accompanying late or early spark. All parts of the device in connection with the timer proper are made of the best suited materials in case-hardened steel, etc., to give the greatest strength and wearing qualities. The complete outfit is attachable to any single or double cylinder Ferro motor constructed with a detachable cylinder head, and the replacement can be quickly accomplished by careful observance of printed instructions.

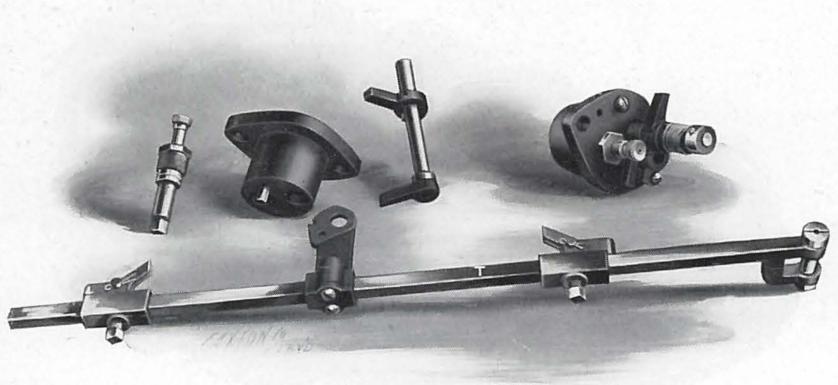


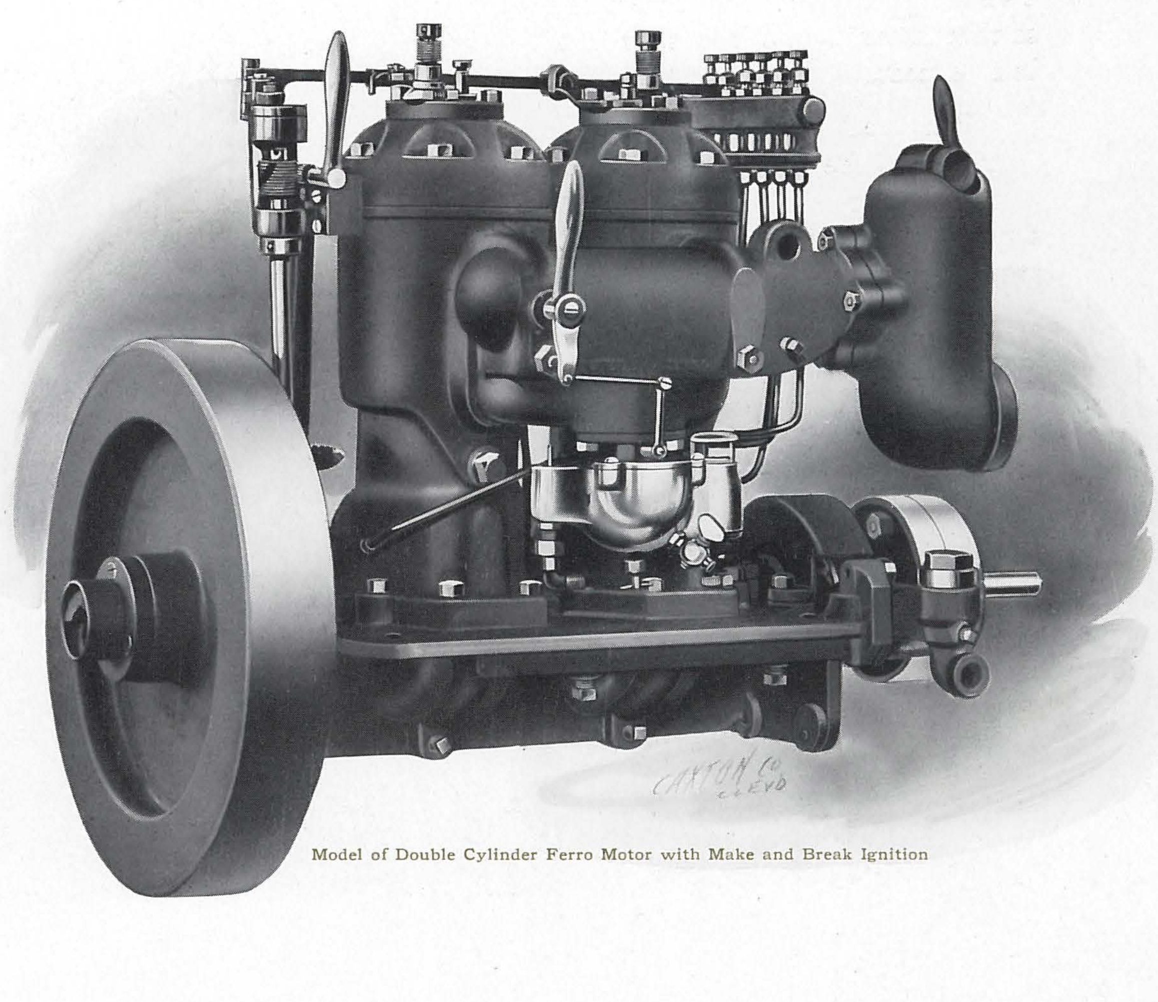
Fig. 6

A PRACTICAL TREATISE ON MARINE GASOLINE ENGINES

The reader being familiar with the detail construction of the Ferro make and break ignition from the foregoing description, he can better understand the general application of it by reference to the illustration of the double cylinder Ferro make and break motor shown on this page. The timer and timer-shaft revolve, their action being hardly perceptable, while the action of the trip rod is a slight forward and backward movement.

This model of Ferro motor is designed for the use of a large class of trade who may desire to utilize a combination of gasoline and kerosene to operate their motors. The burnt kerosene carbon deposit in the cylinder requires occasional removal to give the best results. In consideration of these conditions, the Ferro make and break ignition mechanism has been constructed so that it requires but the detachment of the trip-rod to take off one or both cylinder heads, thus giving free access to the cylinders.

NOTE:—To those interested in the application of kerosene as a fuel for a gasoline motor, the Ferro Machine & Foundry Company publish a phamplet on this subject which is mailed free on application.



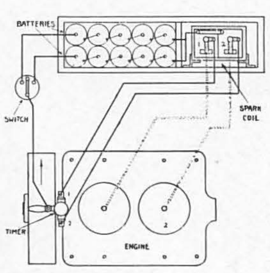
Model of Double Cylinder Ferro Motor with Make and Break Ignition

Installation of Ignition

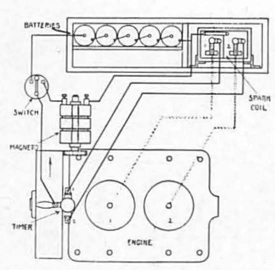
TO give our reader a more accurate idea of the wiring for the various ignition systems than is possible to follow out from the foregoing illustrations, we publish herein several wiring diagrams covering the use of batteries alone, and with the combination of batteries with the magneto, which apply to both single and multiple cylinder motors. The dotted lines represent the heavily insulated secondary wires that lead from the coil to the spark plug. This wire, it is well to remember, is the high tension wire which we have already described as conducting a very high voltage of electricity and which current it is hard to confine to the wire if it comes in contact with any object that also serves as a conductor for the electricity. Hence it is necessary to use the utmost precaution to see that the secondary wire is placed as directly as possible from the coil to the spark plug with few intermediate contacts in supporting the wire.

All portions of the jump spark wiring system as well as the batteries, coil and plugs must be well protected from water, spray and even moist air, for they all have a detrimental effect upon it. Nothing but the very best grade of wire should be used, particularly for the secondary current, to insure satisfactory results at all times. It is essential to have every wire connection made with a clean contact and rigidly fastened so that it cannot work loose with vibration and cause failure of ignition perhaps when least expected.

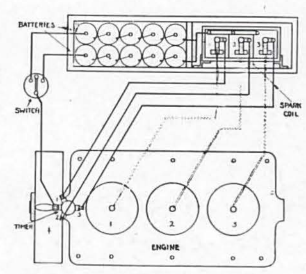
When using batteries only, it is well to have two sets of five or six each, switching from one to the other alternately. This allows one set to recuperate while the other is in operation. It will be found to add greatly to the life of the batteries. Where a motor is receiving steady use, it is advisable to install a magneto, depending upon the batteries to start with only, or for emergency in case of possible mishap to the magneto.



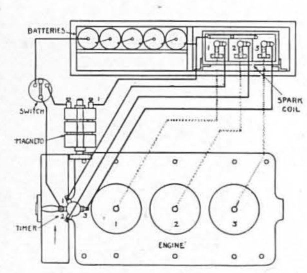
Wiring Diagram with Batteries for two Cylinders



Wiring Diagram with Batteries and Magneto for two Cylinders

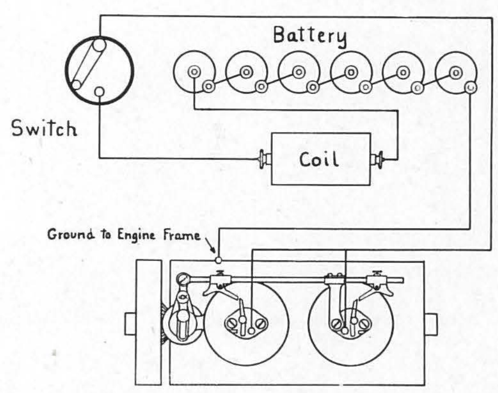


Wiring Diagram with Batteries for three Cylinders

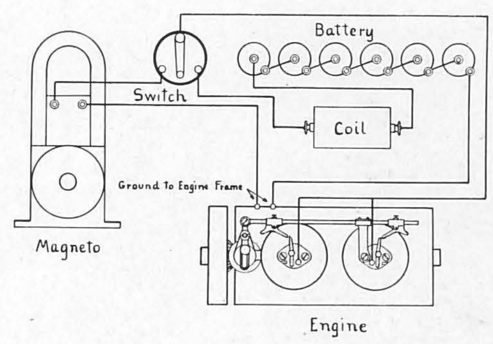


Wiring Diagram with Batteries and Magneto for three Cylinders

Make and Break System



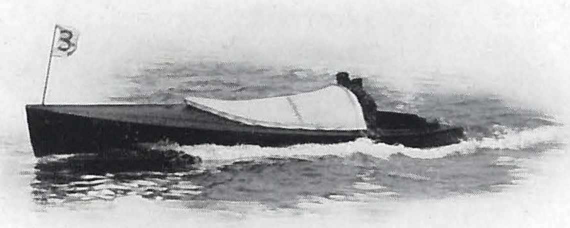
Wiring Diagram with Batteries for Two Cylinder Make and Break



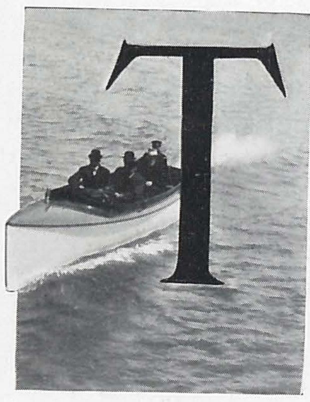
Wiring Diagram with Batteries and Magneto for Two Cylinder Make and Break

The Make and Break ignition system, although somewhat similar to the Jump Spark, is much simpler to understand and install. The wiring diagrams illustrated herein show the most satisfactory method used with both the batteries and the combination of a dynamo. The same arguments in favor of this combination are true with the Make and Break system as they are with the Jump Spark.

There are no high tension currents of electricity with the Make and Break ignition, but nevertheless, care should be exercised that wires do not cross or come in contact with one another so as to destroy the proper course of the electricity. The coil used with this system differs from that of the Jump Spark in that there is no vibrator to it. The construction of this coil, in a word, is a spool of wire wound around an iron core. It serves to store the electricity for each successive operation of the igniting points thereby imparting greater force to the current, resulting in a bright hot spark in the cylinder. The sparking points must be kept free from accumulation of burnt carbon or else it will interfere with a good spark if not result in its failure. It is of course essential to keep the mechanism of the Make and Break system amply lubricated with the frequent application of a first class machine oil. The practice of cleanliness with both ignition systems as well as with the motor is a remarkable safe-guard against trouble and it will be found in evidence with the best operating motors.



Cooling System



THERE are two methods commonly used to cool a gas engine cylinder, namely, water and air. Both methods are in successful operation today. The water method consists essentially of a pump, Fig. 1, and a hollow pocket around the cylinder through which the water is forced and kept in constant circulation. The air method consists of a series of ribs or fins (Fig. 2.) arranged around the cylinder thus presenting a large radiating surface over which is usually blown a constant stream of air by employing a rotary fan similar in design to the ordinary electric fan, such as we often see in offices and stores. For marine work, where water is at hand, it is far more practical and convenient to employ it as a means of cooling the cylinder, than air. The air cooled cylinder is far more liable to become overheated, unless some further means is employed to increase the circulation of air. Note the clean cut appearance of the straight line cooling water system, free from air pockets, in the accompanying phantom view of the Ferro engine (Fig. 4). The cylinder jacket gets the proper supply, and discharges it. The past prevalent idea that any arrangement, so long as it provided water in contact with exterior cylinder walls, was sufficient to cool a gasoline engine, is still clinging to many marine engine makers' designs. The foremost stationary and automobile engine men long ago realized that unless the cooling problem received careful study they would sacrifice both power and efficiency, to say nothing of money for needless repairs. The coolest water in the jackets is near the bottom. The hottest part of the cool part of the jacket is where the exhaust comes from the engine. At that point the cold water supplied by the pump enters, and passing up and around between the walls of the cylinder and jacket, discharges at the extreme top of the cylinder. A generous sized concealed trunk main delivers the water to the cylinder, and a similar concealed duct receives the discharge from the cylinder jacket and carries it to the exhaust condenser, which leads exhaust noiselessly to side of boat or through bottom. No matter how hard you run the engine, day or night, in tropic or polar regions, there is always the same ample supply. It is not a cheap system; it is a high grade one.

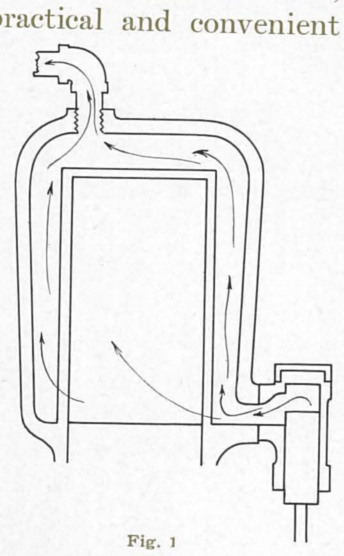


Fig. 1

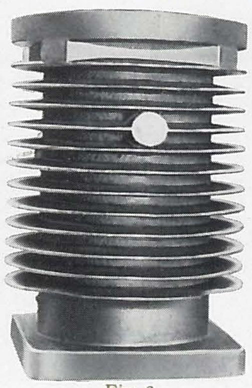
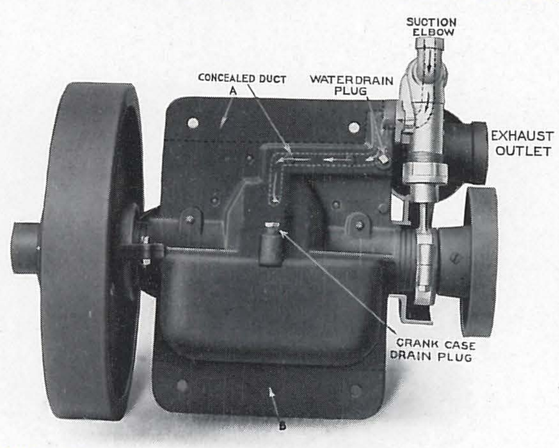


Fig. 2



Water Channels and Drain Plugs on bottom of Ferro Motor

In frosty or freezing weather particular attention must be given to the draining of all water jackets and channels. This can be done by simply removing the water drain plug at the end of the water channel under the crank case (see illustration) and loosening vent plug in top of the cylinder.

If desirable for greater convenience, a pet cock may be inserted by the owner in place of the channel plug.

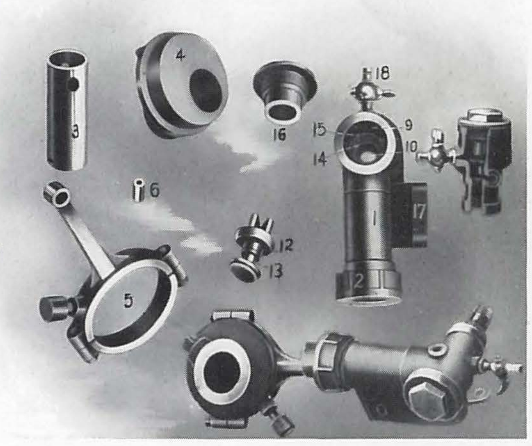


Fig. 3

Pump

Water-pumps work most efficiently for windmills, steam boilers, etc., with scarcely any attention. On most marine gasoline engines the pump is usually a slighted feature.

It is, however, a very important part of the motor and must be specially designed to supply water to the cylinder jacket in as steady proportion, as the speed of the motor may require. Fig. 3 shows the Ferro patent circulating pump properly constructed. 1 is the barrel and 2 the stuffing box, in which the hollow piston, 3, works, driven by the eccentric, 4, whose strap, 5, is pivoted to piston by the pin, 6. The eccentric is bolted to the crank shaft by a screw. The suction nipple is connected by a hose with seacock and intake passing through bottom of boat, so that water enters valve chamber, 9, by hole, 10. The combination of suction valve and discharge valve, 12, is clearly shown. Stem, 13, of suction valve, slides in discharge valve. Both valves drop into valve chamber and make tight, easy fits on their respective seats, 14 and 15. The bonnet, 16 which closes valve chamber, permits of instant inspection. The pump discharges into concealed feed main, where it bolts by flange, 17, to engine frame. A try cock, 18, drains the entire pump. If grit should cut the valve seats, it is a simple operation to grind them in by applying a little emery and oil on the valve seats and turning both valves in place by the wings shown on top of discharge valve.

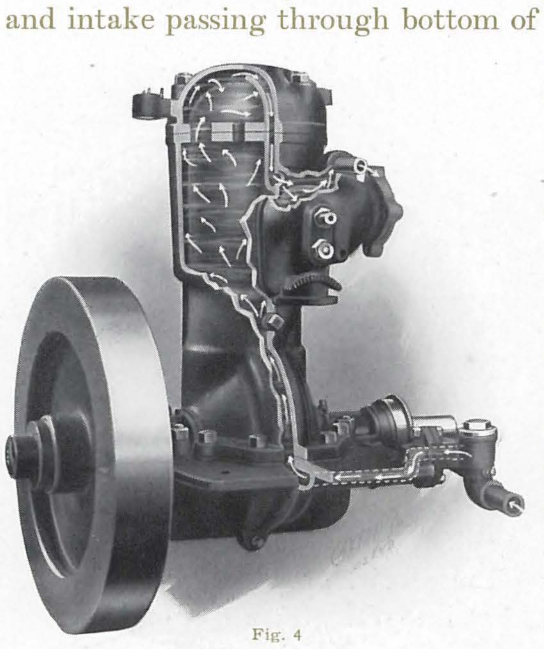


Fig. 4

The action of the pump may be facilitated in drawing the water from the seacock or intake, by placing a scoop over the opening of the intake pipe. This scoop is a crown-shaped disc with two long openings on the side that catch the water when the boat is moving forward. The force of this action is usually sufficient to lift the water to the pump. A bronze metal scoop of special design is furnished with every Ferro motor. An illustration of it is shown in groups of equipments, page 69.

Lubrication

WHEN two surfaces move across each other there is generated a certain amount of friction. Friction produces heat and as heat is a form of energy, it follows that energy is lost as friction is encouraged. To eliminate lost energy and wear produced by friction, the surfaces must move as smoothly as possible. This is accomplished by oil. Theoretically the oil film keeps the atoms of the two surfaces from actual contact. In actual practice we know that if for any reason the oil is destroyed or withheld, the surfaces rub or bind. If there is one thing more than another that should receive the attention of the best skill of mechanics, it is the oiling system of a gasoline engine. The cylinder of a steam engine is never hotter than the steam, and besides, the particles of water in the steam aid the oil in reducing the friction. With the gasoline engine the temperature of the cylinder space is the temperature of the combustion of mixture — hot enough to consume any oil. Therefore the method of lubricating must be especially suited to high temperature, i. e. oil must be used which will vaporize when it finds its way into the combustion space and not carbonize and cake. Since the lubricant, which is fed to the cylinder, is constantly consumed by intense heat, it is necessary to feed slowly just sufficient oil to give perfect lubrication, but the supply must be constant and never failing. Fig. 1 illustrates the positive pressure reservoir sight feed oiling system as applied to single and multiple cylinder Ferro engines. There are, broadly speaking, four vital points in a gasoline engine, which must positively be oiled—the cylinder, piston, crank pin and crank shaft main bearings.

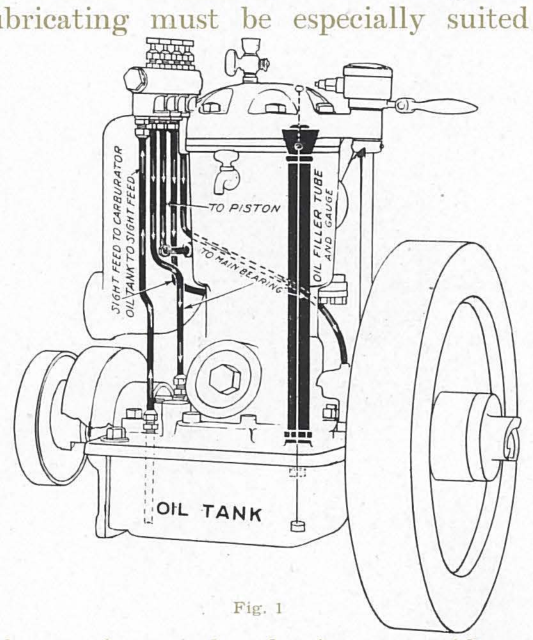


Fig. 1

The positive pressure oiling system of the Ferro engine takes nothing for granted and provides a system which works just as surely as the engine works, forcing a uniform constant supply of oil to every bearing surface in the exact amount for each. It starts automatically and works with the engine. The simplicity of the entire device is shown in Fig. 2. The oil reservoir, a separate air tight compartment, is cast integral with the crank case. A short tube with a check valve, connects the crank chamber to reservoir. At each revolution pressure is stored in the reservoir, and thus serves to force oil up to the sight-feed distributor through a feed tube. From the bottom of each sight-feed valve, an oil tube leads directly to the vital

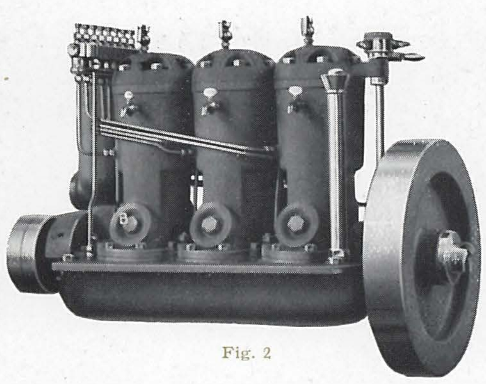


Fig. 2

part of each bearing. In a single-cylinder engine there are four sight-feed valves and tubes; in a two-cylinder engine, six, etc. The system of distribution is as follows: The tube leading to the cylinder conducts the oil direct to its inside wall at a point in line with the hollow piston pin and oil grooves of piston. The oil passes through the piston pin to opposite walls of cylinder and is collected in the oil grooves, picked up by the piston rings and distributed by the up-and-down motion of the piston to every portion of the rubbing surface. The tube leading to each main bearing cap conducts the oil through the caps to the rotating crank shaft, and thence through holes drilled from main bearing portions of crank shaft to crank pin, as shown in Fig. 3, (dotted line). Each ball thrust bearing also receives its quota of oil from the adjoining main bearing cap. Thus it will be seen that every vital bearing in the Ferro engine is supplied directly with a positive feed supply of lubricating oil. Each sight-feed-valve can be instantly adjusted to deliver a "drop by drop" supply to its respective bearing. As an additional precaution a tube is led to the carburetor where the oil is vaporized and fed to all interior parts of the engine.

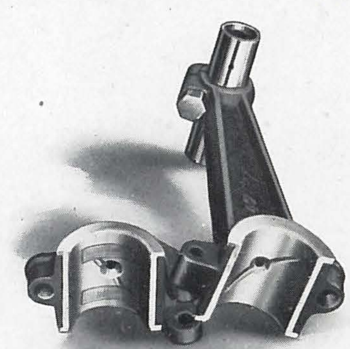


Fig. 4

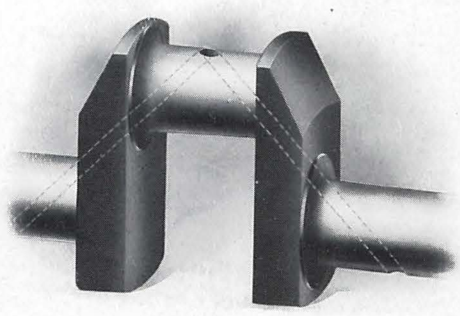
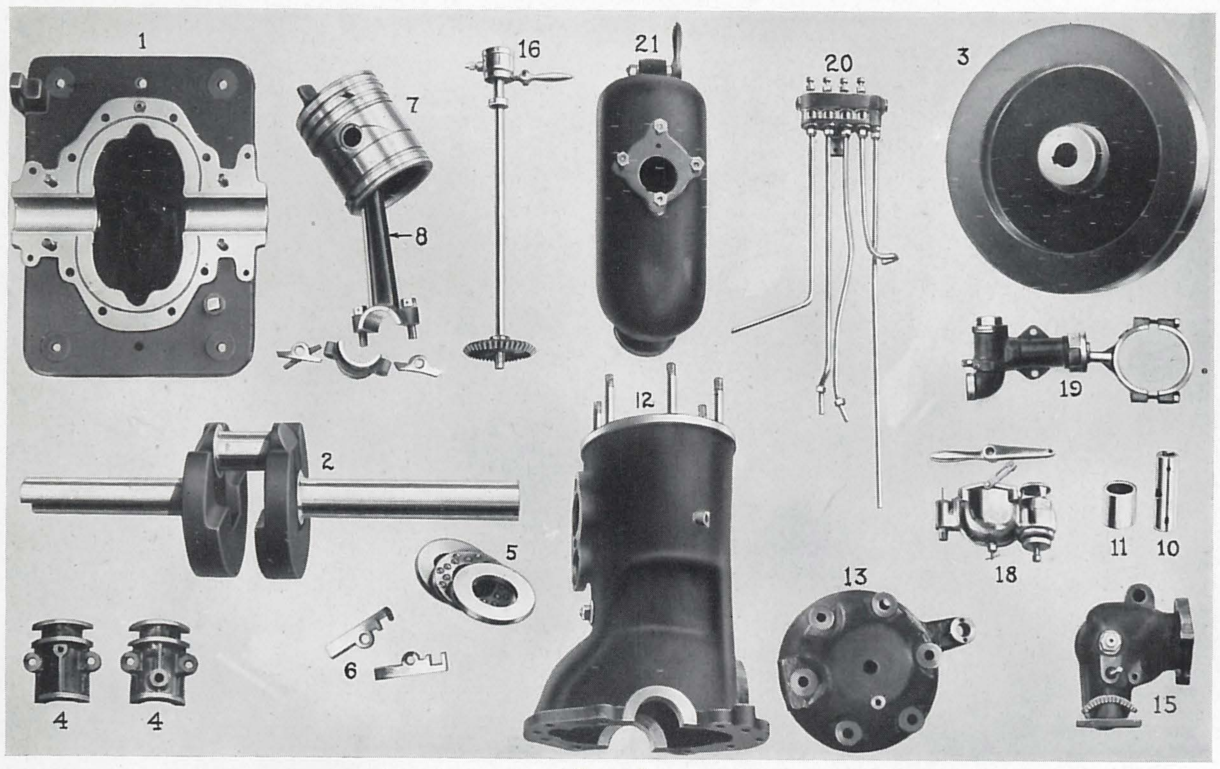


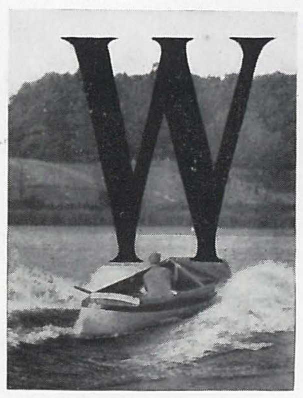
Fig. 3

In addition, the regular "splash-feed" system, universally used by marine engine builders, is supplied with each engine as an auxiliary safeguard against carelessness or ignorance. It consists of two wicks in the end of the connecting cap, (Fig. 4.) operating on the crank pin which constantly feed oil to this bearing. The oil which settles down into the bottom of this crank case forms a pool which is thus splashed all over the interior by the rapid revolutions of the crank. This system while not a reliable one for general oiling, is valuable as an emergency feature, and should only be depended on as such. All surplus gritty settlings are drawn off periodically through the plugs visible in crank case bottom.



Group A

Assembling a Ferro Motor



WE will now build up the motor from a complete set of disassembled parts illustrated in the group above. Each part, it will be observed, has its number which, together with its name, is referred to when assembling it into its place on the motor. At the same time we will endeavor to explain what each part is, what it is constructed of, its function, etc. Assuming that our reader is not technically educated, we have avoided the use of mechanical drawings, utilizing photographs of each part and assembled groups to describe our subject to him in a most comprehensive manner. Moreover, the use of scientific phrases or descriptions has been avoided in order to give him the clearest possible conception of what comprises all the various parts of a marine gasoline motor.

It is an unfortunate practice of a large number of marine motor purchasers, particularly amongst initial buyers, that they take their motors all apart in order to learn how they are constructed and put together. A motor, as it comes from the factory, is put together and tested by experts. The inexperienced man who attempts to take his motor apart and put it back just as it was, will invariably fail in correctly reassembling it, which leads to his expense of having this work done at the factory or hiring a competent man to do it. Therefore, the object of this article is to assist the reader in knowing the general construction and assembly of the two-cycle motor as applied to the Ferro, so that the owner or operator of this motor at least, should not find it necessary to dissect it to become acquainted with its mechanism.

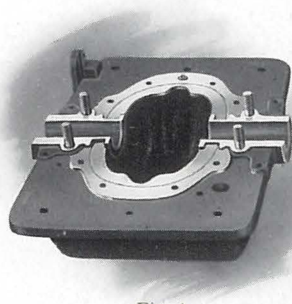


Fig. 1

Fig. 1 is the crank case or the lower part of it, forming the base of the motor that rests upon the foundation timbers in the boat. It is an iron casting and must be made heavily for it is a part of the motor upon which there is considerable strain. You will see that it possesses the main bearings for the crank shaft, upon which bearings there is always a down thrust. Hence, these bearings must be constructed of ample sizes in length and width for the distribution of oil, and to minimize friction and wear.

The crank shaft, Fig. 2, is a revolving part of the motor upon which all the power of the engine is exerted in operation. In transmitting this power at high speed it is requisite that the crank shaft be made of the toughest material, namely, high carbon steel forged to shape. This crank is made heavier and stronger than is necessary in order to produce a factor of safety beyond a doubt. Iron weights are placed opposite the crank so as to balance the weight of the crank together with the piston and connecting rod bearing upon it. The machine grinding done on the crank shaft insures an accurate interchangeable fit as well as a smooth running bearing surface. The crank shaft turns in a specially prepared bearing metal, called babbitt.

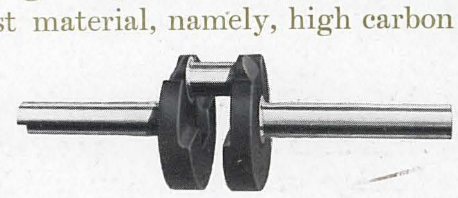
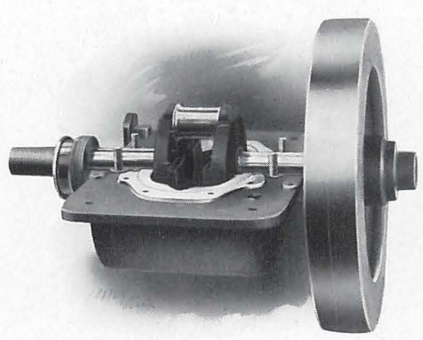


Fig. 2



Group B

Group B shows the shaft with the fly-wheel set in position and ready for bearing caps, Fig. 4, which hold the crank snugly in its bearings. These bronze caps are set up on brass shims, Fig. 6, so as to allow for a fine adjustment of the caps in case of any wear in the babbitt metal which would result in a loose bearing.

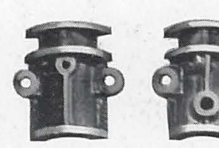
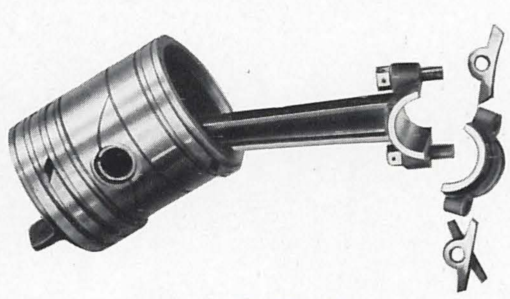


Fig. 4

In Fig. 7 and 8 the piston and connecting rod are pictured. The piston is a hard casting set with four piston rings Fig. 9. These rings are machined a little larger than the piston and possess enough outward spring to keep them snug against the cylinder wall; hence, their purpose is to prevent any escape of gases by the piston when the explosion occurs. The bearing surfaces of the piston and rings are ground to an exact size. These ground surfaces reduce friction with the piston in its fast travel up and down in the cylinder.



Figs. 7 and 8

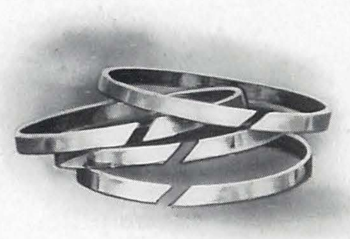
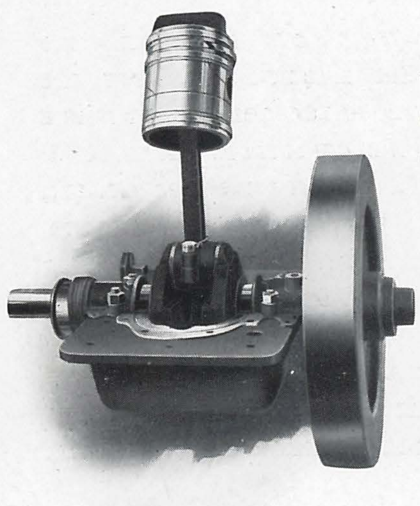


Fig 9



Group C

The connecting rod transmits all the power from the piston to the crank shaft, therefore, must also be strongly constructed with tough material like the crank shaft, namely, a steel forging. Its upper bearing to the piston is a hollow, hardened steel pin Fig. 10, turning in bronze metal or bushings, Fig. 11. Its lower bearing you will note, is very similar to the main bearings, babbitt metal being used and an adjustable cap with shims forming a snug fit to the crank. In Group C, we have placed the connecting rod and piston in place on the motor, showing the steel wire between the cap screws to keep them from loosening.

Fig. 11

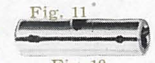


Fig. 10

We are now ready to place the cylinder in its position as in Group D. The cylinder itself (Fig. 12) is a high grade iron casting which with its cover or cylinder head, Fig. 13, forms the upper half of the engine proper. A maximum pressure of from three hundred to five hundred pounds to the square inch is created in the cylinder of a combustion motor at every explosion. Thus, like the base and working parts, the cylinder must be constructed strongly and heavily but not excessively so, as has been the practice in the construction of all parts of some marine gasoline engines in the past. The interior cylinder wall is also ground out to an accurate fit and polished to receive the piston. Group D shows a hand hole through which a wrench can be applied to remove the cap on the connecting rod.

Fig. 12

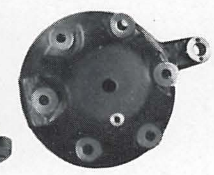
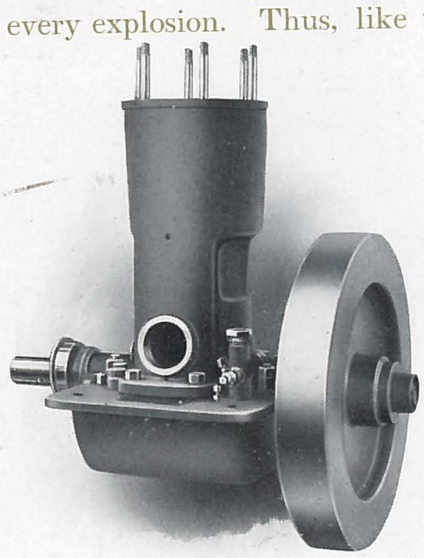


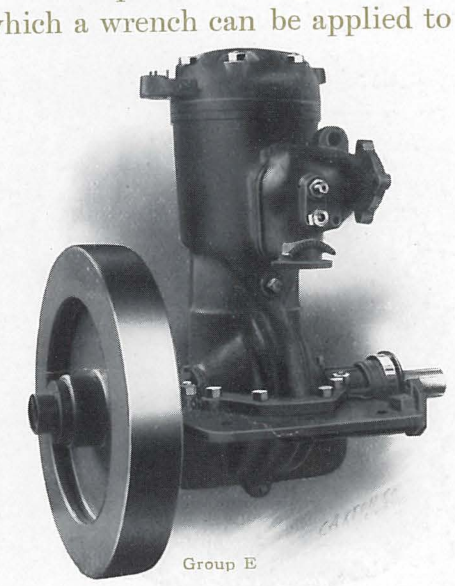
Fig 13



Group D

This hand hole is especially advantageous in that it not only permits the entrance of the hand and wrench, but also serves to allow a view of the entire interior of the crank case with the aid of a light, advisably, an electric lamp.

In taking the motor down, one will readily note that with the cylinder head and hand hole plate off, free access is given to the interior of the motor for the easy removal of the piston and connecting rod, without otherwise disturbing the motor or its parts.



Group E

Fig. 15

Group E shows the further assembly of parts with the cylinder head, Fig. 13, and the exhaust and intake manifold, Fig. 15, bolted in position. Both pieces are castings, each possessing their water jackets and having accurately machined surfaces where they join the cylinder.

The complete sparking timer or commutator, as it is sometimes called, is shown in Fig 16.

It comprises the timer body at the top, in which revolves the contact device, properly called a commutator. It is attached to and revolves on the timer shaft. The bevel gear on the lower end engages a similar gear attached to the fly wheel, off of which the timer device is driven. The complete timing apparatus which is made of bronze metal is shown assembled on the motor in Group F.

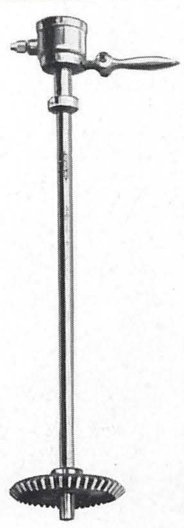


Fig. 16

Positive feed and circulation of water with the marine motor is necessary. For this reason it must be equipped with a positive force or pressure pump, either of the plunger or piston type. It is made entirely of brass to give best wearing qualities, and also to be serviceable for salt water. In the body of the pump are two valves, one to hold the water lifted from the intake pipe, another to hold the water forced from the pump. It will be seen from Group F that the pump is attached directly to the base of the motor where the channels or ducts in the castings convey the water from the pump to the cylinder. The plunger or piston of the pump is driven off of an eccentric on the crank shaft by means of the combined connecting rod and strap. The strap is constructed in halves as shown in Fig. 19, so that it can be easily removed or adjusted. The carburetor (Fig. 18), the details and functions of which are fully described on pages 8 and 9, is made entirely of brass, excepting the float feed which is cork. The body of the carburetor is one casting, and the top piece forming the cover and flange connection to the intake header, another. There are several other minor parts, the separate cover for the carbureter air intake, etc., that make up the complete assembly. By reference to Group F, it can be seen that the carburetor is firmly affixed to the motor with but two bolts which are easily accessible with a flat wrench or a common bicycle wrench, so that with the placing of the throttle lever upon exhaust header and making the connection to the carburetor valve this portion of the assembly is quickly and easily accomplished.

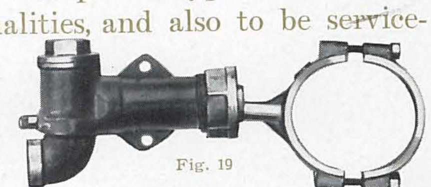


Fig. 19

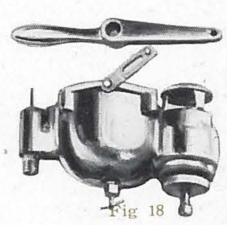
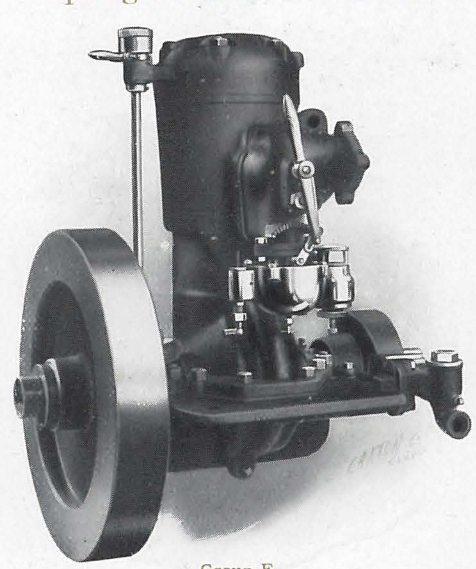


Fig. 18



Group F


Fig. 21

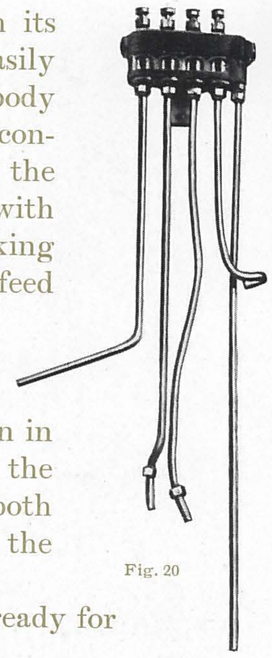
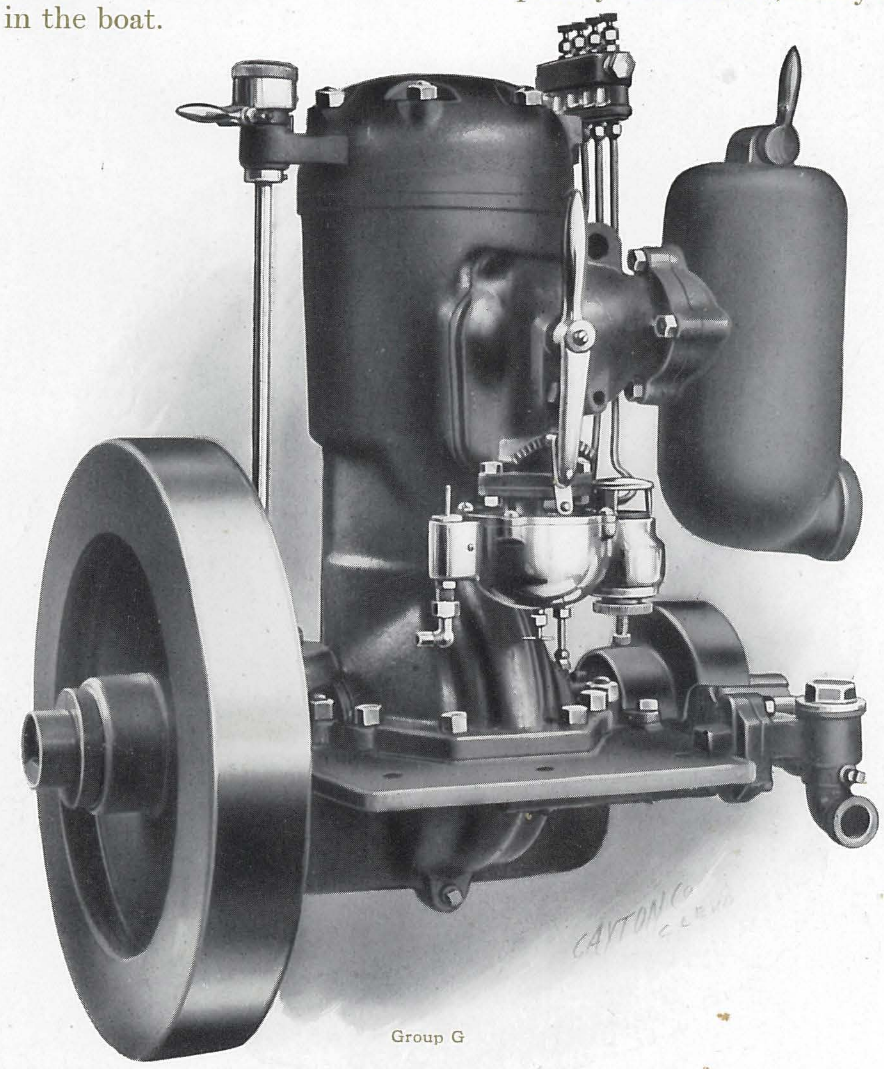


Fig. 20

In Fig. 20, the Sight Feed Oil Distributor, with its various oil tubes, is shown. The tubes are soft brass, easily bent for connection to their respective bearings. The body of the distributor is cast brass, the upper portion of it containing a chamber where the lubricant is forced from the oil tank through a feed tube. The distributor is cast with a bracket which fastens on the cylinder. Small packing nuts affix the oil tubes to both distributor and their feed connections.

Fig. 21 shows the Expansion Chamber or Exhaust Condenser. It is an iron casting, hollow inside with a vent valve at the top. The large opening, as shown in cut, connects directly with the exhaust discharge on the exhaust header of the motor, four bolts fastening both pieces firmly together. The small opening above the exhaust is the duct for water injection into the condenser.

In the group below is shown the motor completely asssembled, ready for installation in the boat.


Group G

The Offset Cylinder

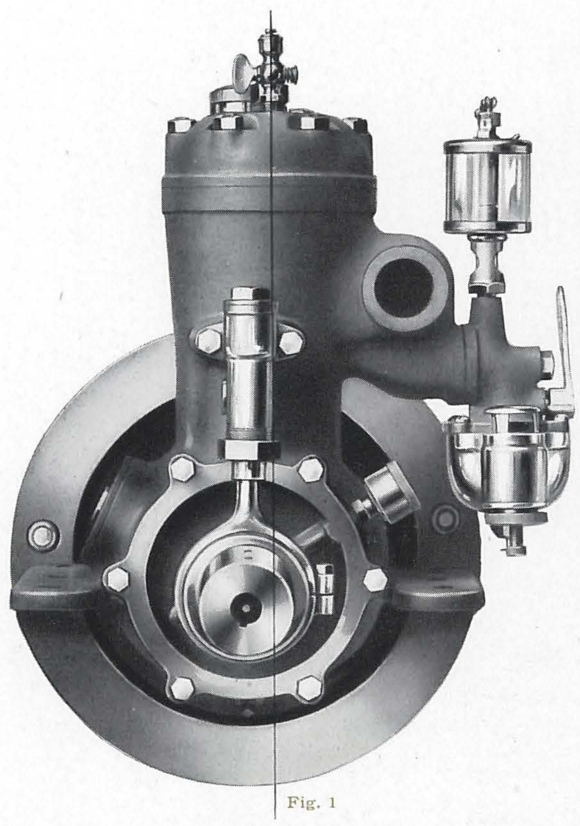


Fig. 1

An idea of the construction of the Offset Cylinder can be best drawn from the illustrations, figures 1 and 3. It will be observed that with the piston at the top of stroke, its center, as compared with the center of crank shaft, has a slight deviation. Fig. 2 shows the usual method of construction with the center of both crank shaft and cylinder in perfect alignment.

It is the common practice of motor-boat men to operate their engines, while at cruising speed, on either a late spark or with the firing point at the top of the piston stroke. In the latter case by reference to Fig. 3 it will be observed that the impulse of the explosion is not directed upon the dead center as in Fig. 2, but that the transmission of the energy is exerted upon the crank shaft in a turning position as in Fig. 3. The connecting rod in descending on the impulse stroke has practically a vertical position, thus more directly transmitting the energy from the piston to the crank shaft.

The Offset Cylinder procures from the motor its maximum power and efficiency, reduces and equalizes the side thrust upon the cylinder wall on the impulse stroke and furthermore eliminates the knock which always tends towards loosening of parts, and premature decay of the motor. This feature of offset cylinder construction will be found on some of the most successful automobile motors being built today.

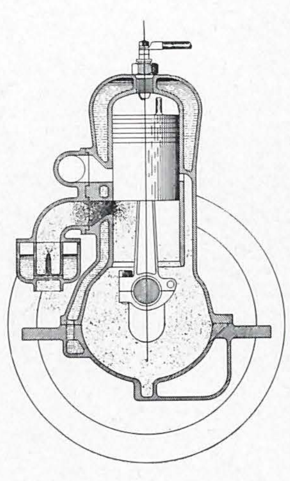


Fig. 2

The line drawing, Fig. 2, represents the ordinary construction with straight center line. The position of the piston as shown is at explosion center. The explosion exerts no turning effort to the crank shaft, for the thrust is exerted on the dead center and falls on the bearings.

In Fig. 3, the offset construction is represented with the piston in same position as Fig. 2, at firing center. It will be observed that the crank, however, is not at dead center, and that the impulse or thrust will be imparted to it in a turning position. No energy is wasted, and no undue shock given the bearings.

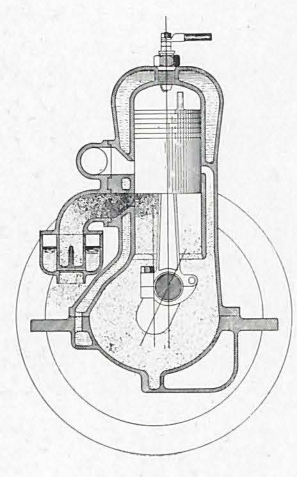
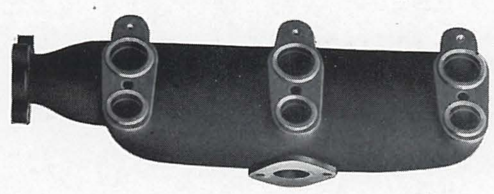


Fig. 3

Combination Water-Jacketed Intake and Exhaust Header

If atmospheric conditions were always suitable, and the gasoline used of good grade, the intake header would not be such a problem. In the Ferro Water-jacketed Intake and Exhaust Header these conditions are met so that a uniform mixture is equally distributed to the cylinder under all circumstances. Sometimes with the intake header, where it is a separate and distinct casting, if the gasoline used is of poor grade, or the weather is such that the air taken in at carburetor will not readily vaporize, the mixture after passing through the carburetor into the intake header will partially condense (the gasoline helps this condensation as it has a refrigerating effect on the vapor), and naturally cause the cylinders to miss fire occasionally.

The Intake and Exhaust Header for the multiple cylinder motor, the three cylinder particularly, has the carburetor placed in the center or directly abreast of the middle cylinder. To prevent this middle cylinder from drawing the gasoline mixture direct from the carburetor, it is necessary to construct a partition in the intake passage or chamber of the header, so that the mixture is distributed evenly to each cylinder; that is, the mixture must be well vaporized and of proper consistency before it enters the cylinders in order to give the best combustion and power producing results.

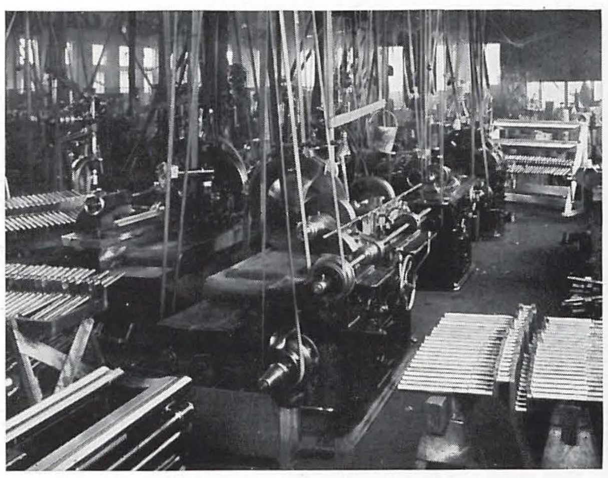


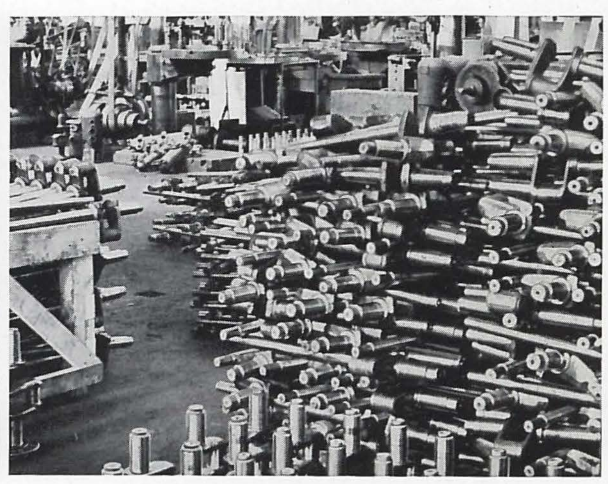
Intake and Exhaust Header for a Three-Cylinder Engine

On the 1909 Ferro engine the intake and exhaust header are combined and water-jacketed. The water about the exhaust compartment is heated and this heated water warms the intake header. By this method the interior of intake header is practically the same temperature (about 78 degrees) at all times. This temperature in the header prevents condensation of the mixture, and as it is always the same, the gas will naturally always be uniformly distributed to the different cylinders.

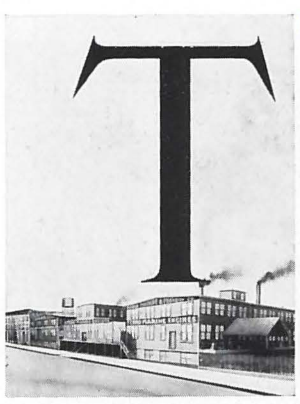
Elsewhere in this book we have taken up the subject of mufflers, explaining their construction, functions, etc. The Ferro Exhaust Condenser or Expansion Chamber, illustrated in the accompanying cut, is attached directly to the outlet of the exhaust header, above described. It is, in a sense, a muffler in that its purpose is to condense the hot gases by cooling them as they pass from the cylinder, also permitting these hot gases to expand, which tends to reduce the noise or report of the discharge at the exhaust pipe outlet. Again, the purpose of the Ferro exhaust condenser is to assist in overcoming any back pressure with the underwater outlet. A small jet of water is injected into this condenser, which reduces the high temperature of the hot gases. This water generates steam, which coming into contact with the cooler exhaust pipe, condenses into water again, leaving a partial vacuum. This vacuum helps overcome any pressure of exhaust gases existing in the condenser or pipe.

Ferro Condenser or Expansion Chamber



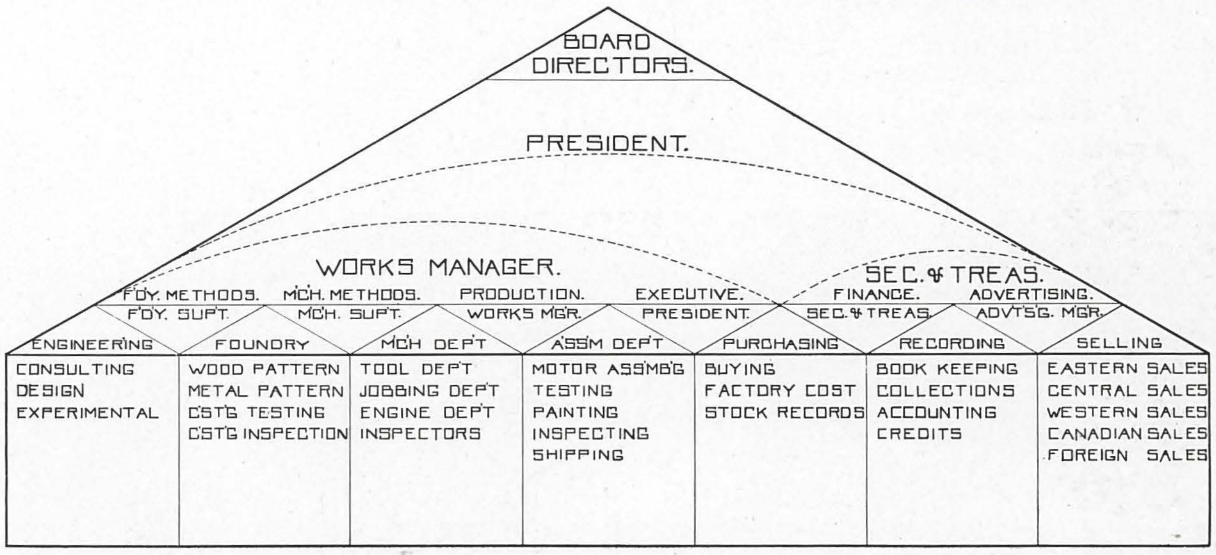


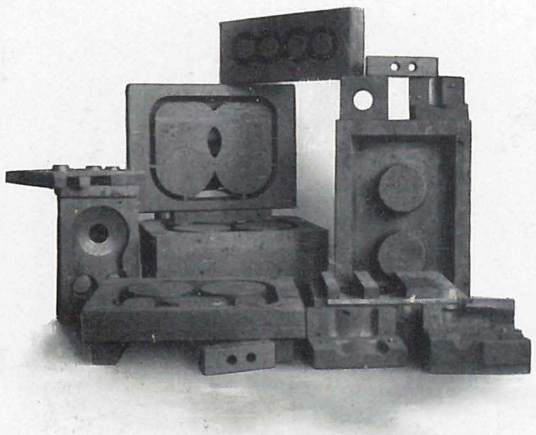
Manufacturing Marine Motors



TO enable our readers to have some conception of how a big plant turns out large quantities of its product daily, the type of organization that is essential in managing and operating an up-to-date successful institution, as represented in the Ferro Company, we illustrate herewith a plan of organization which is so arranged that each department has distinct duties in the development of details necessary to design, manufacture, advertise and sell the product of an immense plant. Each detail is turned over to the proper department, and before being put into practical operation, is passed on by the committee in charge of that particular line of work.

It has always been the belief of the Ferro organization that to reach the goal of perfection, it is necessary to specialize on one type of marine motor and centralize the brains of the entire organization on that one type. Therefore the same general design has been carried out on all Ferro engines, but in order to give the reader a

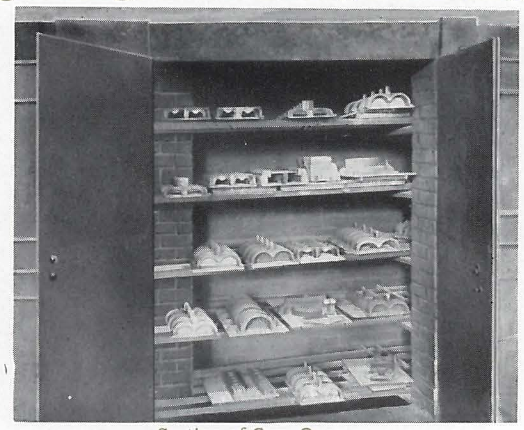



Group of Core Boxes

clear understanding of the systematic method in which all Ferro engines are built, we will endeavor to take him on a trip through our plant from the starting of the blue prints to the finished motor, describing as briefly as possible the detailed attention given to each part by the designing and manufacturing departments.

The designing and experimental departments are in charge of engineers who have had practical experience in the development of stationary, marine and automobile gasoline engines, as well as the benefit of knowledge gained from the correspondence of thousands of operators now using Ferro engines in all parts of the world, under all conditions, in every kind of service and with all kinds of fuel.

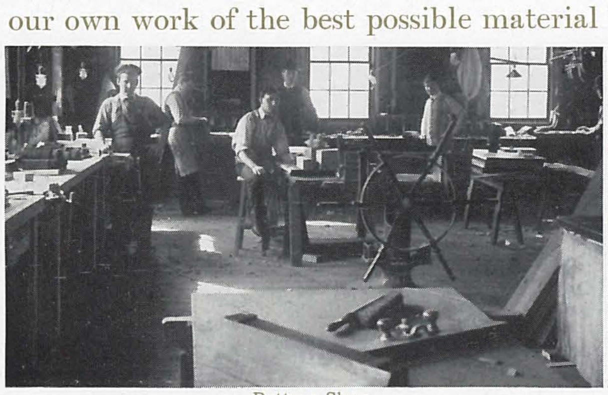
In the 1909 model, it has not been necessary to make any radical departure from the previous design. The combined efforts of the engineering, manufacturing and selling organizations have been centered on simplifying detail construction so as to develop a motor that is perfectly safe in the hands of the inexperienced operator.

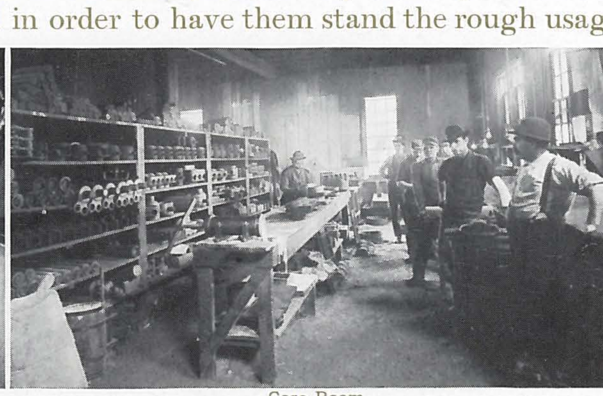

Section of Core Oven

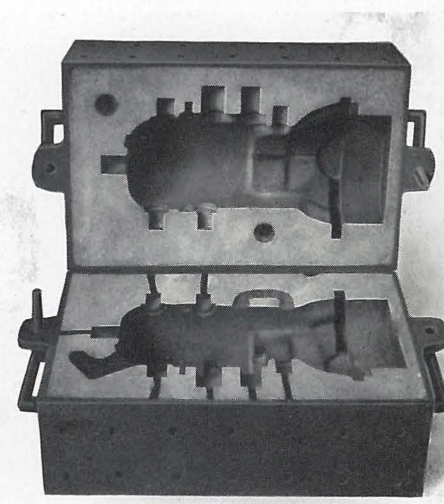
Every new improvement has been thoroughly tested in our experimental department, also on our especially designed testing apparatus, as well as in actual use on our testing boats and by the large boat builders who are using our engines.

During the entire time that the tests were being made on these improved parts, the heads of the departments were studying the manufacture of every detail as carefully as they previously discussed the design.

In continuing our trip to the pattern shop, we find the department equipped with the latest modern labor-saving machinery especially adapted for the production of accurate wood and metal patterns. We have found it economical practice to produce patterns for our own work of the best possible material in order to have them stand the rough usage


Pattern Shop

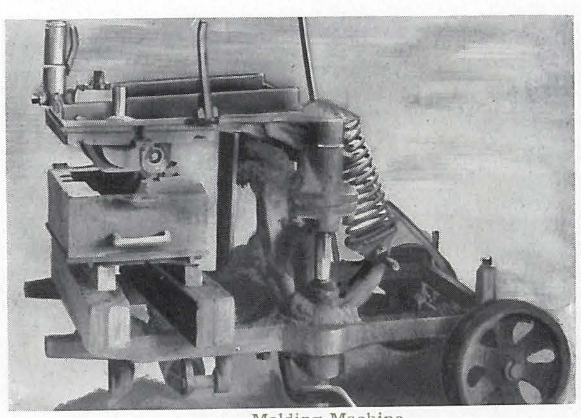

Core Room


Cylinder Mold in Flask

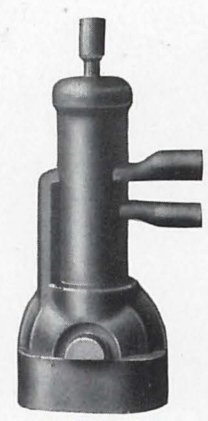
they are given in the molding department, and therefore, wherever possible, all patterns are made of metal, also the core boxes, as this practice insures perfect castings.

After passing through the pattern shop, the next department that would be visited is the foundry.

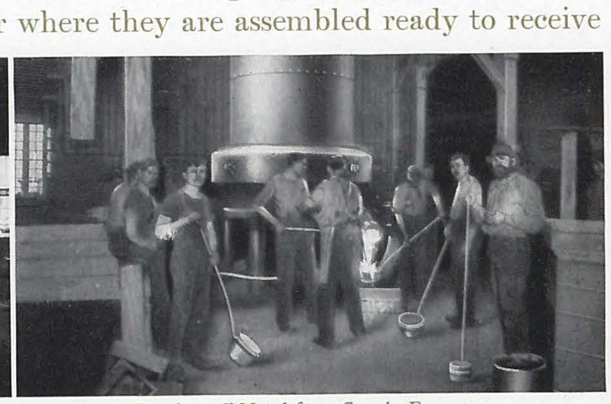
The core department first attracts our attention with its score of skilled workmen making intricate cores which go to make up the water jackets and interior sections of the cast iron and bronze parts of the motor. These cores are constructed of a fine sand such as found on the bank of a lake, or of a pulverized sand stone which is mixed with a binding compound and pressed into shape in core boxes from which they are removed and then baked in large ovens in about the same manner in which bread is baked. After this baking process, the core is firm enough to stand handling and is ready to be placed in the mold.


Molding Machine

We next pass on into the foundry where the molds are being made. In this department we find the old time hand molding methods discarded and modern molding machinery substituted, as it is a step necessary to insure uniform thickness of castings. In the making of molds the pattern is fastened rigidly to the machine and is surrounded by an iron box or flask. This box is filled with sand and rammed hard so that it will take the exact shape of the pattern, as well as sustain its own weight, after which the pattern is withdrawn by compressed air and the mold is removed to a large baking oven and baked the same as the cores. This baking process hardens the mold and prevents crushing during the final assembling operations. The molds and cores are next taken to the casting floor where they are assembled ready to receive


Cylinder Core


Casting Floor, Air Furnace in Back-ground


Pouring off Metal from Cupola Furnace


View of Foundry Floor

the melted iron. During this assembling operation, each part is put in place and measured with special gauges. Extreme care is used to see that no small particles of sand crumble from the core or mold, as they would lodge in the casting and cause it to be rejected by the foundry inspection department.

The molds are now ready to receive the molten iron which has to be of several different grades to meet the requirements of the different pieces. This has made it necessary to equip the foundry with two melting outfits. One is a cupola in which we melt the iron used in the balance wheel and such other parts which are not subjected to any severe strain, the other outfit consists of a reverberatory or air furnace which produces the high grade iron we use in cylinders and pistons.

It may be of interest to the reader to know what a reverberatory or air furnace is. Most of us are more or less familiar with the cupola.

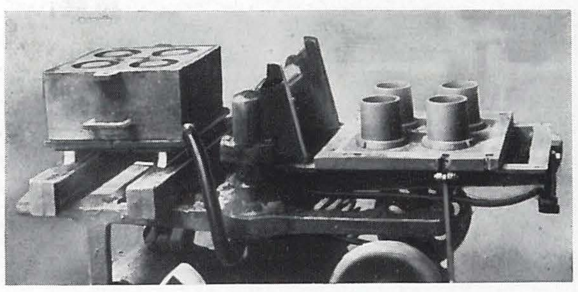
To bring iron to a molten condition requires intense heat. The rapid chemical action of carbon and oxygen produces combustion and its consequent heat. The source of oxygen is of course in the air. Therefore, it is necessary to supply air in sufficient quantity to produce the necessary heat to melt iron.

The cupola furnace is equipped with a power blower and shaft from which air is forced into the furnace in proper quantity to produce the best possible combustion of all the gases, part of which would otherwise be lost by the absence of oxygen. The action of the cupola furnace upon the iron in melting it, is to permanently alter its original chemical properties or elements. This chemical change of the iron in making castings with the cupola for many common varieties of uses is not of vital importance, so long as the proper strength and consistency of the metal is retained for its particular use.

The air furnace is very similar to the common stove and fire place used in the home, in that air is supplied by natural forces of draft from a chimney or a flue. A tall smoke stack is used with the air furnace, the strong draft of which provides air beneath the grates in proper quantity to make perfect combustion and heat.

The construction of this furnace is such that the fire itself does not come into direct contact with the iron while melting. The heat from the combustion is deflected or reverberated to the iron and thus this type of furnace derives its name. Chemical alteration in the elements of the iron is by far more gradual with the air furnace than with other types. For this reason it is possible to pour from it the same composition of iron that is put into it. A valuable advantage with the air furnace is that the heated metal can be drawn at intervals during the melting to make both chemical and physical tests. This enables the heated metal to be treated so as to finally pour metal of the exact proper consistency desired. The facilities of testing the molten metal and absolute control of the air furnace are not possible with the cupola.

The type of iron required for the casting of gas engine cylinders must combine the greatest tensile strength in a light construction, also reasonable qualities for fine machining. It has been found that the metal produced with the air furnace, although at far greater expense, is close grained and tough, yet still more satisfactory to machine. The air furnace metal is being used by the leading automobile manufacturers, and it is this same metal that is used to cast the Ferro cylinders.



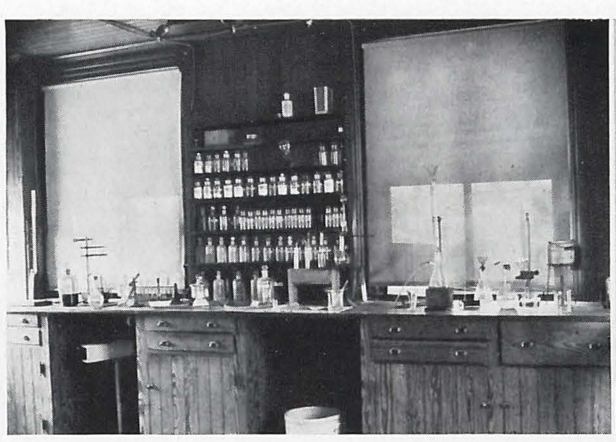
Molding Machine

After the castings are made they are sent to a cleaning department, where all the sand is carefully removed and they are given their first inspection; such parts that are required to stand pressure are tested with either air or water.

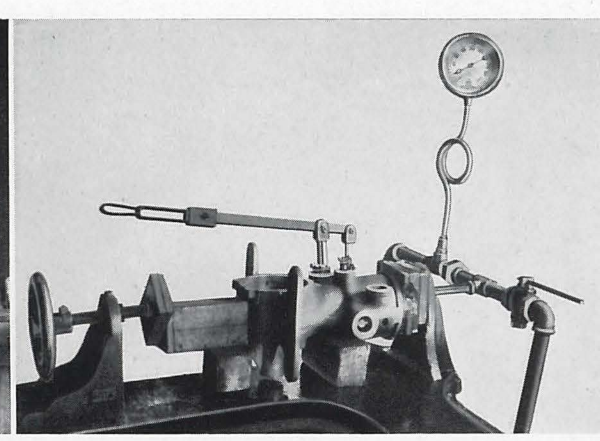
There is a separate department in the foundry for making brass and bronze castings, which allows us to give special attention to the grade of material used in all bearings and propeller wheels.

The mixing of all iron and brass is in charge of our chemist with a well equipped laboratory at his disposal.

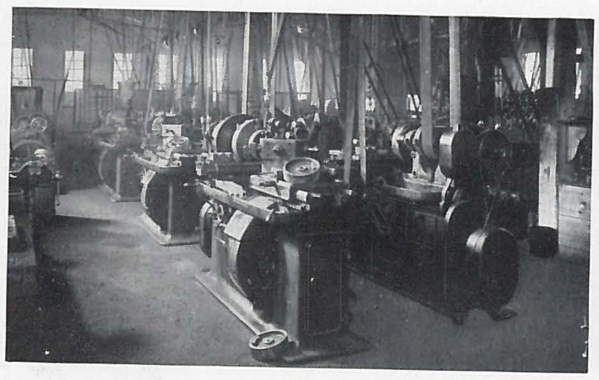
The work of making patterns, cores, molds, pouring metal, testing and inspecting with painstaking care, as we have seen so far, is only the first step in the making of a successful marine motor. What we are ready to see now is the machine shop where these castings, from their rough condition, are wrought into form and finished with the same accuracy and delicacy as a finely made watch. In this article it is hardly possible for us to go into details with our reader other than to describe to him briefly the machining processes in the completion of the principal parts of a marine motor, and endeavor by the illustrations herein to give him a more thorough conception of the work than it would be possible for us to do in words.

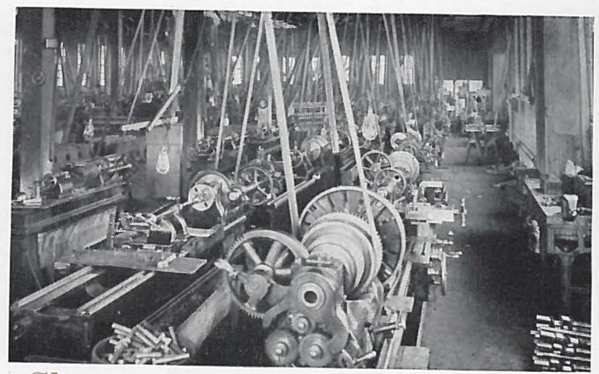


Chemical Laboratory



Hydraulic Tester for Cylinders





Machine Shop

The visitor, on entering the machine shop, might probably expect to see rows of lathes, drills, planers, shapers, and the various other general types of machines to be found in a regular jobbing plant.

Here, however, he will find that, although there are these types of machines, they are all special and designed to do one particular class of marine engine work, or as in some cases, to do only one operation, for example, cylinder boring. Not only are these machines special for a particular work, but it will also be observed that many of them are automatic in their operation, requiring the machinist but to place the work in position, then set them in operation.

Hand Lathe

The points to be observed by the reader in going through the machine shop are the accuracy with which each operation is performed, moreover the despatch with which each motor part is machined. We call attention to the bulk of material which each machine operator has beside him. His work is given him in quantities of several hundred, so that he sets his machine only once and then proceeds with his work until he has completed the entire stock of that motor part.

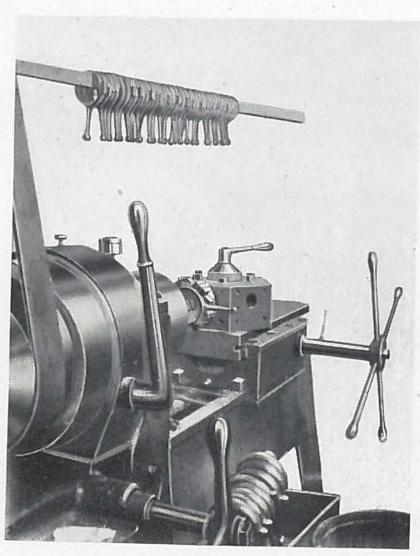


Fig. 1

To better illustrate the above you will note in the accompanying cut, Fig. 1, an automatic turret lathe for finishing pump eccentric straps. The unfinished strap is slipped into a special holder and is held rigidly in position while the cutter tool smoothly machines its inner surface and outer edge, Fig. 2.

The complete operation from start to finish in this instance takes but twenty seconds. These developed facilities for rapid and accurate work make possible a minimum manufacturing cost and the consequent reduction of selling price to consumer.

In order to give our reader a more explicit understanding of some of the detail machine work, we will take as an illustration a small cylinder in the rough casting, Fig. 3. After cleaning and inspecting in the foundry

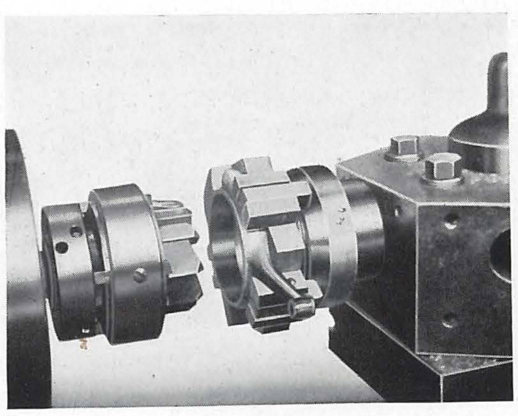
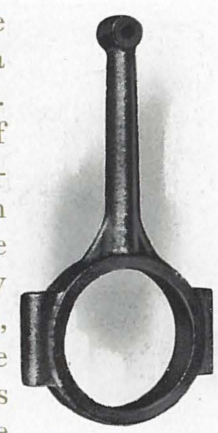


Fig. 2



Rough Eccentric Pump Strap

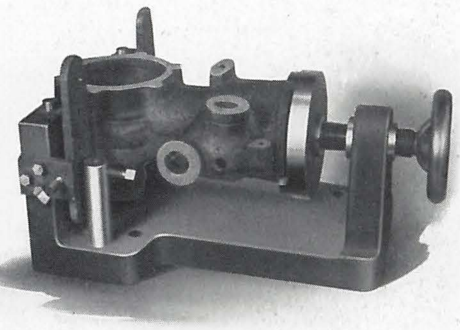
department it is brought into the machine shop and fastened in a special form which is called a jig. This jig, like all others, is made of hard steel in the tool making department. Its purpose is to clutch its work and maintain absolute accuracy in the machining of every cylinder placed in it; not only that, but to duplicate the same relative accuracy with each cylinder so as to make them interchangeable without the slightest deviation when putting them together. This same jig is used for every cylinder of the particular model and size we are describing herein. Referring to Fig. 6, "A" indicates a wheel clamp which holds the cylinder in position in the jig, which is also the function of the screws "B" and "C".

Fig. 3

With the work thus set in position in the jig, it is placed upon a boring mill and all the machining work necessary for the facing of crank case surfaces is done in one operation. At the arrow "D" is indicated a fixed steel gauge or rule on the jig which shows the machinist when the operation has been completed, at which time he stops the machine and removes the work.

We next call attention to the combination tool which is shown ready to be set in operation. The arrow "E" indicates the boring tool that finishes the crank shaft bearing operation and the cutters indicated at "F" face off the inner and outer rim or surfaces for the end bearing. This tool is made of one solid piece of metal, allowing no deviation in the alignment of its work.

The fact should be particularly borne in mind that from this first machining operation on the cylinder, every following operation is gauged. In other words, from the surfaces first machined, as above, every cylinder in the following operations has its bearing in the respective jigs until the work on the cylinder is completed. This insures perfect alignment in gauging each successive operation.



Cylinder Jig

The cylinder is now removed from this first jig, set upon another similar form, then placed in a multiple drill press, Fig. 5, where, in one operation the several holes are bored for the bolts or screws which hold the end plate or crank case cover.

After this operation the cylinder is again mounted upon another jig, which sets it in an upright position so that a vertical boring machine roughly finishes the interior of the cylinder proper.

In Fig. 7 is pictured the cylinder being bored

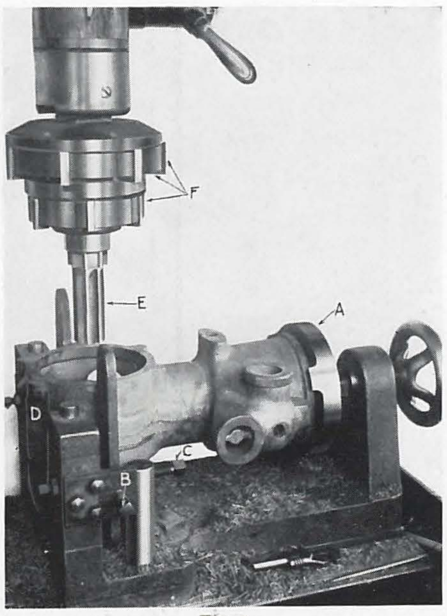


Fig. 4

by a special machine, preparatory to its grinding and polishing finish. The operations in this machine are three: 1, the cylinder boring above mentioned; 2, facing off the top surfaces of the cylinder; 3, facing off the small surface on the outer edge of cylinder.

Fig. 7. shows the cylinder mounted again upon another individual jig, similar to the others, but specially designed for the grinding machine. On the end of the spindle indicated by "A" there is a small emery wheel which is belted to revolve at about five thousand revolutions per minute. In addition to this speed motion, the spindle also rotates slowly around the interior of the cylinder wall, the emery wheel removing little by little the interior surface of the cylinder until it is ground out to the diameter required and measures to a thousandth part of an inch according to a special gauge.

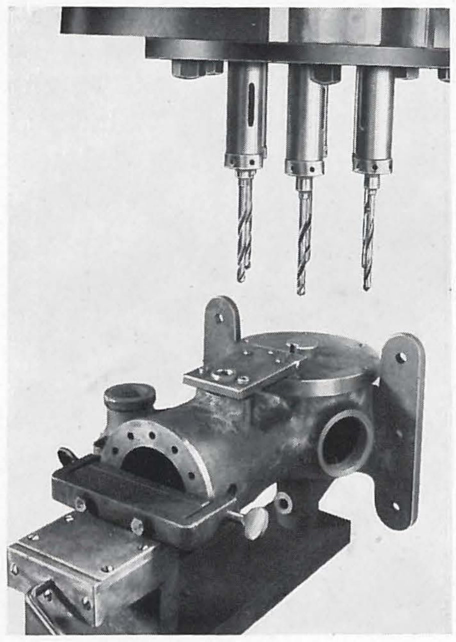


Fig. 5

With the completion of the several operations above enumerated, the cylinder proper is practically completed except the facing off a few minor surfaces, drilling and tapping several holes for various connections and fixture attachments.

In the machining of all iron and steel parts of the motor it is essential to treat the metal specially, for it has the peculiar nature of slightly changing or distorting its form under certain conditions. For example, with the rough casting, if the machine work were done before removing the scale and projecting particles of metal, the casting would be found to have changed its shape or form to a mechanical inaccuracy. For the same reason it is the best practice to allow a casting to rest, as it were, after each machining process and particularly so before final operation. The recognition of such details is essential to maintain interchangeability and standard of all motor parts.

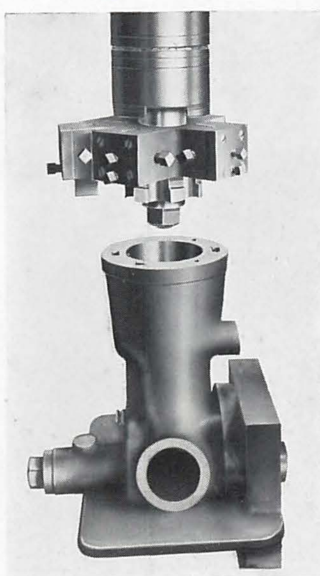


Fig. 6

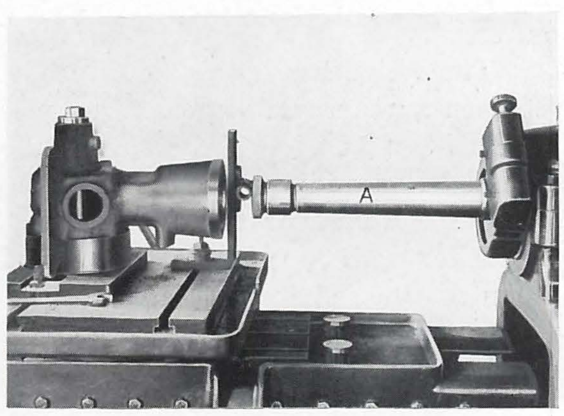


Fig. 7

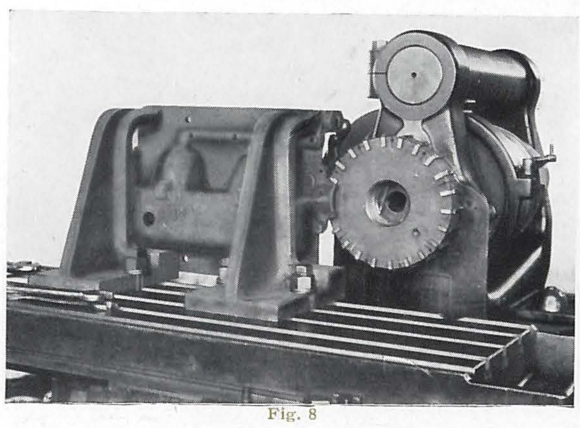
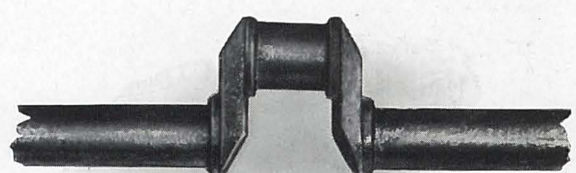


Fig. 8

By the term "interchangeability" and "standard" is meant that each motor part is made identically for every motor of a particular model that a manufacturer produces. Thus, if you broke the crank shaft on your motor, were it made interchangeable, you could replace it by simply communicating with the factory and getting a new one. No fitting or alterations to either crank shaft or motor would be necessary.

We will now step over to where the crank cases for standard Ferro engines are being machined. The principal operation performed on this engine part is the facing off of the surface on which the cylinder is fastened, which work is done in a milling machine. The accompanying cut (Fig. 8.) will give the reader an idea how the crank case is set up and machined with special tools, the complete operation consuming but a few moments. This piece of work is now dismounted and upon the surface thus machined, a template is placed, which serves to guide the drills accurately in the operation of boring holes for the studs or bolts which fasten the crank case and cylinder together. Fig. 9 pictures a similar operation of the multiple drill upon a cylinder casting. From this operation the work is passed on to a power tapping device which threads these holes to receive the studs or bolts. After this last operation, there are a few other minor ones which entirely complete the crank case of the engine, ready for assembling. With the machining of the crank shaft the same treatment of the metal is carried out as mentioned above in this article, in that the scale is removed and all rough surfaces made smooth before the final grinding. The crank shaft and connecting rod are parts of the engine that are



Rough Crank Shaft

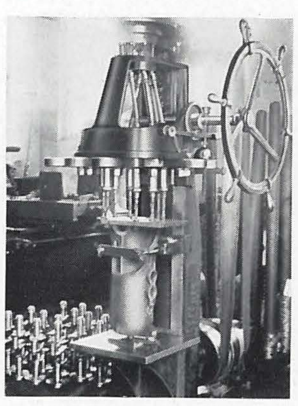


Fig. 9

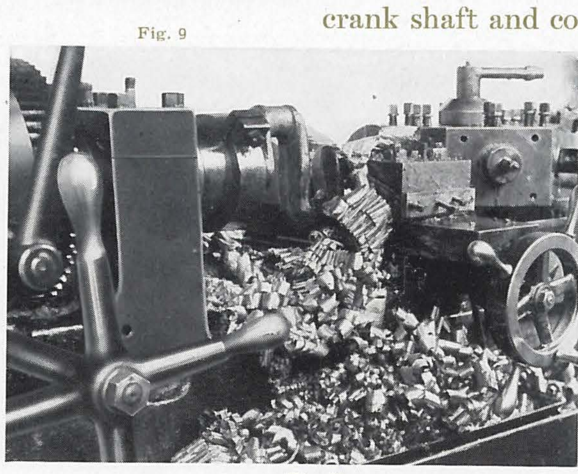


Fig. 10

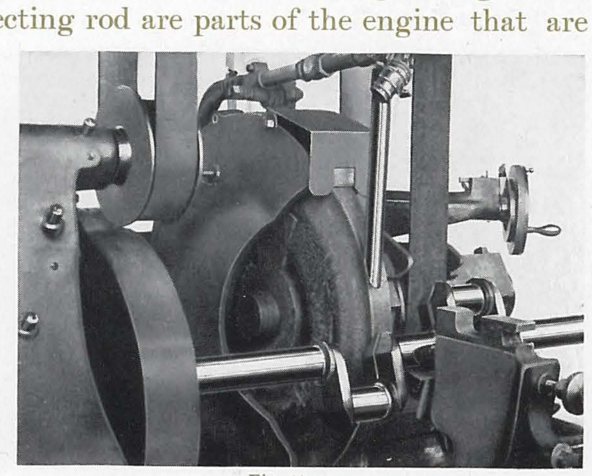
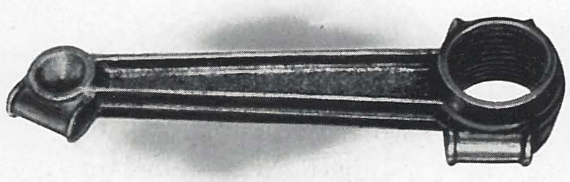


Fig. 11



Rough Forged Connecting Rod

subjected to tremendous shock and vibration which set up an action in the metal causing it to gradually become crystalized and brittle like hard steel or glass. In this latter condition it is very liable to sudden breakage with an unusual strain or jar. Hence it is necessary to overcome this liability of breakage by a heated treatment of the metal, which permits it to withstand excessive vibration and strain without weakening or undue crystalization. The crank shaft is first placed in a jig and a special lathe employed to complete a roughing cut. The Fig. 10 shows the rapidity with which this operation is completed by the heavy cut that the tool makes in this metal, which is hard and tough. With the completion of this operation the crank shaft is set in another jig and placed in a grinding machine (Fig. 11.) where all the rounded bearing surfaces are ground to a thousandth part of an inch to their required size. It is now ready for assembling with the exception of a few minor operations.

Rough Piston Casting

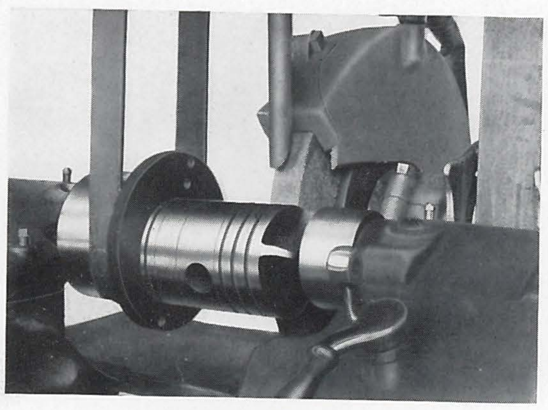


Fig. 12

The principal work on the connecting rod is the machining of the lower end that fastens to the crank shaft. We can best describe this work by calling attention to the accompanying Fig. 12 in which there are a series of connecting rods set in the form. A combination of milling cutters completes the entire work in one operation. This machine is so arranged that while one set of connecting rods is being machined, the machinist can arrange another series for a similar operation immediately upon the completion of the first.

Piston Ring Casting

In machining the piston, the work is largely done in a special automatic turret lathe as illustrated herein, Fig. 13. A roughing cut is made on the sides and grooves

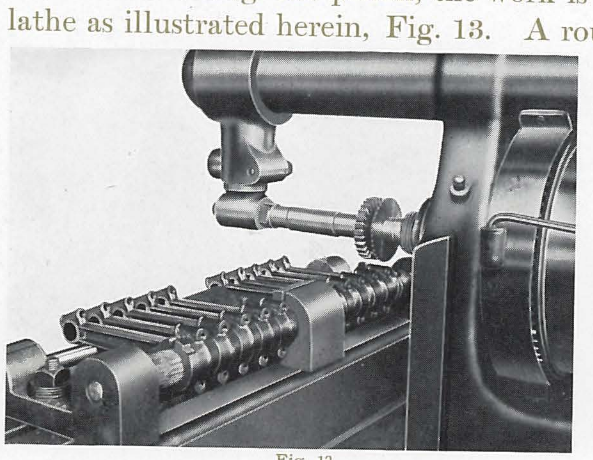


Fig. 13

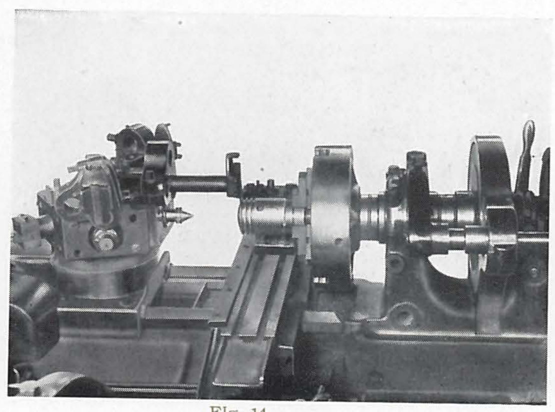


Fig. 14

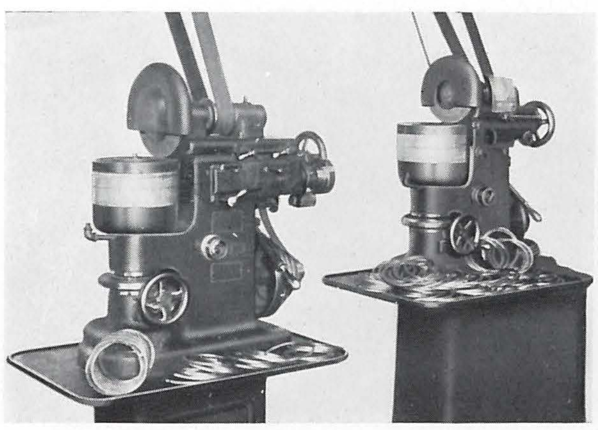


Fig. 15

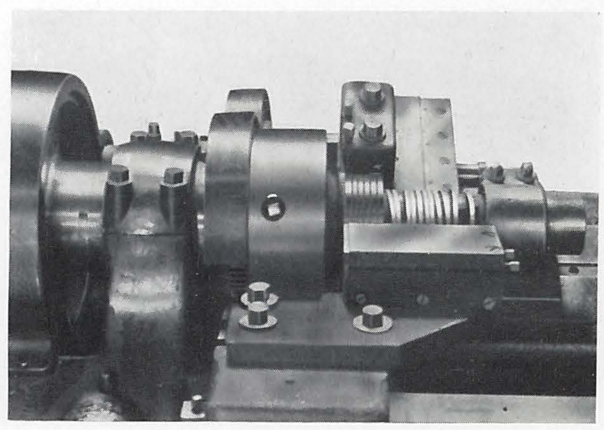


Fig. 16

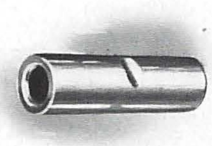
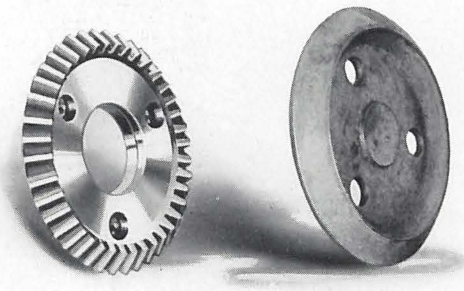


Fig. 17

cut for the piston rings, and for facing off the head, all in one machine with the use of special tools. It is then taken to a grinding machine, Fig. 14, and ground off to an exact size and the last operation is the drilling of the hole for piston pin in a special lathe.

We will now pass on to the automatic piston ring machine which is shown in a detail cut, Fig. 15. This machine is fitted with a set of cutters or a gang tool which, after the machine has roughly cut the interior and exterior walls of the cylindrical castings, cuts off the rings ready for grinding on three of their bearing surfaces. These first operations, it may be concluded, are very accurate and rapid, it being possible to turn out a large stock of these rings in a few days' time. In the accompanying Fig. 16, we show two special grinding machines for polishing and finishing the piston ring surfaces.

Fig. 18



Finished and Rough Timer Gear

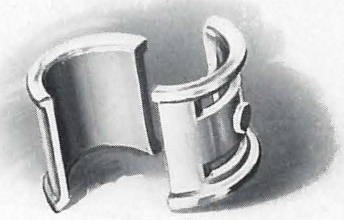


Fig. 20

These machines are equipped with magnetic chucks, which hold the rings rigidly in position while a rapidly revolving emery wheel, similar to the grinding machines, passes back and forth over the rings until they are ground down to an accurately required measurement.

The piston pin shown in Fig. 17, which connects the bearing of the connecting rod to the piston, is made of standard seamless steel tubing. It is put through two machining processes, namely, the making of a groove or slot for the distribution of oil, and a grinding process,

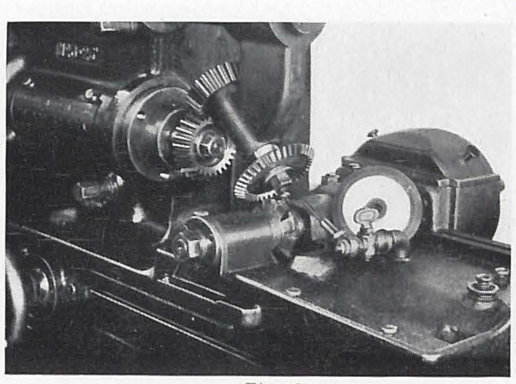
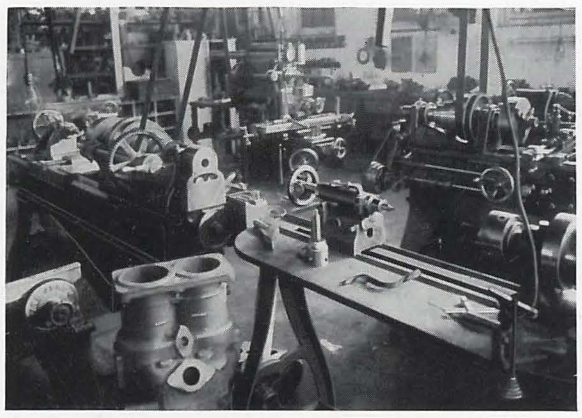


Fig. 19



Tool Room

similar to that of the crank shaft or piston. Before grinding however, this pin is specially treated so as to case-harden or temper the outer shell of the metal, thus making it hard and durable.

The machining of the cylinder head, (Fig. 18.) is very similar to that done on the top of the cylinder to which the head is fastened, in that a combination tool does the work of boring out the interior of the head to a gauged depth, also boring a hole for the spark plug as well as facing off the outer surfaces of the head. One further operation in the multiple drill of boring six holes for the cylinder head studs or bolts completes this piece of work for assembling.

Lastly, we will briefly mention the machining of the timer gears. The castings are first roughly cut and bored for the timer shaft in an automatic turret lathe and then completed in an automatic bevel gear cutter, as shown in Fig. 19.

Fig. 21

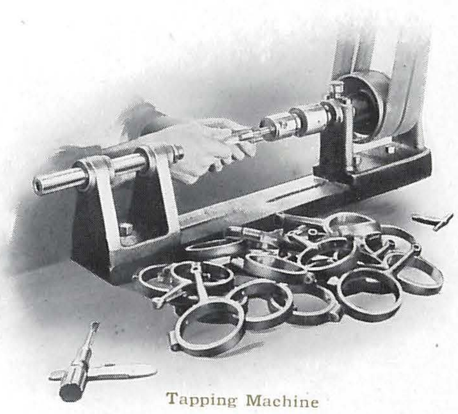
Although we have treated briefly the bearings for the lower connecting rod to crank shaft, we desire to call attention to the interchangeable die cast bearings for the lower connecting rod and crank shaft, the picture of which we show herein, Fig. 20. This die casting process eliminates the necessity of any machining whatever, for each individual casting is made of partially molten metal, which is forced into sharp dies under a pressure, and also creates greater density and toughness of the metal as well as accuracy in finish.

Before leaving the machine shop it will be of interest to our reader to have a glimpse of the tool room where all the special jigs, templates, and many various special tools for machining marine engine parts, are accurately made. When anyone of

Assembling Department

these jigs or templates indicates the slightest deviation from the correct dimensions, it is immediately referred to the tool department for correction and alteration or a new form made to replace it. In Fig. 21. we show only a portion of the many special tools and jigs which are used in the machining of every detail part of a marine motor. Even though skilled mechanics are employed to do their respective work, still the element of mechanical inaccuracy is eliminated to a minimum by the employment of correctly constructed tools as far as it is possible to carry out this process.

Inspection



Tapping Machine

In connection with the machine and tool shops we must not fail to visit the Inspection Department, which is in the hands of the most competent experts. They are furnished with accurately made gauges and templates with which they inspect every piece of work that enters into the construction of the motor before leaving the machine shop. The above illustration shows but a corner of this department with its bench and grist of gauges, etc., all of which play a vital part in the machine shop process.

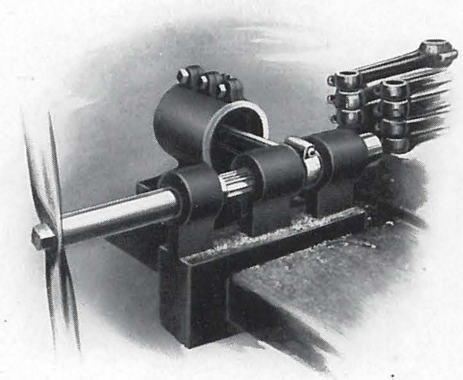


Fig. 23

Assembling

Following the motor parts as they go from the machine shop, we find ourselves in the Assembling Department. Here, at many rows of benches are seen numerous skilled workmen, each a specialist in performing some particular operation in the assembling of the motor. Scattered here and there may also be seen a number of light machines for doing some minor operation, such as drilling holes or tapping threads. To facilitate the rapid progress of the work in this department, it is essential to have the workmen so arranged that each step of assembling may succeed with the least amount of handling, and hence with the least amount of labor and time for the final completion of the motor.

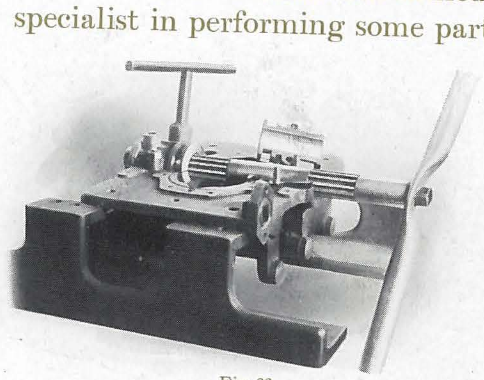


Fig 22

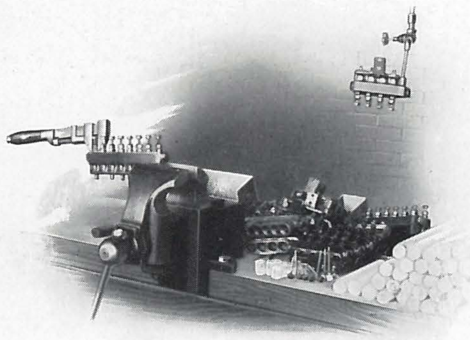


Fig. 25

To maintain the same accuracy of work that is noted in the machineshop, and to avoid carelessness on the part of any of the assemblers, a corps of inspectors will be seen constantly engaged in watching each stage of the motor assembly, and consequently allowing little or no opportunity for any faulty work which would later manifest itself in the testing of the engine, and which, of course, would entail greater expense in the manufacturing cost of the motor.

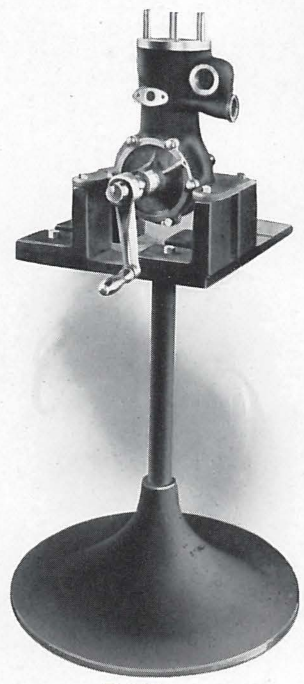


Fig. 26

Taking again a small cylinder as an example, we will follow it to its complete assembly. After the machine shop inspection it is taken and thoroughly cleansed, being freed of all metal chips, etc., after which it is given another rigid hydraulic test. This test will indicate by water leakage any defects which may have been caused by machining, in weakening the walls of the water chamber for instance, or showing up porous spots in the casting, should there be any.

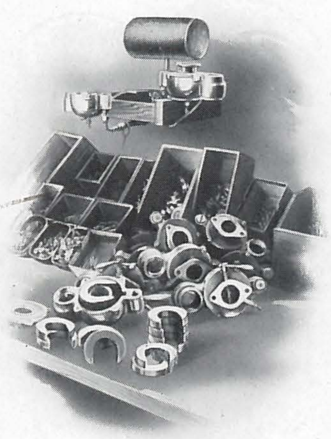


Fig. 24

From this operation, after inspection, it is taken to an assembler who places it on and bolts it to the crank case, whence it goes on down the rows of other assemblers, at each hand receiving some additional part such as timer, carburetor, oiler, header and so on to its final completion.

In the illustration (Fig. 22.) is shown the manner in which the main bearings are trued up with a special boring device, and later scraped to an exact fit to take the crank shaft.

Fig. 27

Fig. 23 shows another group picture of connecting rods, the bearings of which are treated similarly to the main bearings in that the rod is set into a special form and a boring device trues the rod bearing into perfect alignment for the assembly of the crank shaft and piston. The water circulating pump has its initial test after its parts are completely assembled by being placed upon a special rig. This test is practical with the operation of the pump upon the motor and a gauge is used in connection with it to indicate the pressure produced by the pump.

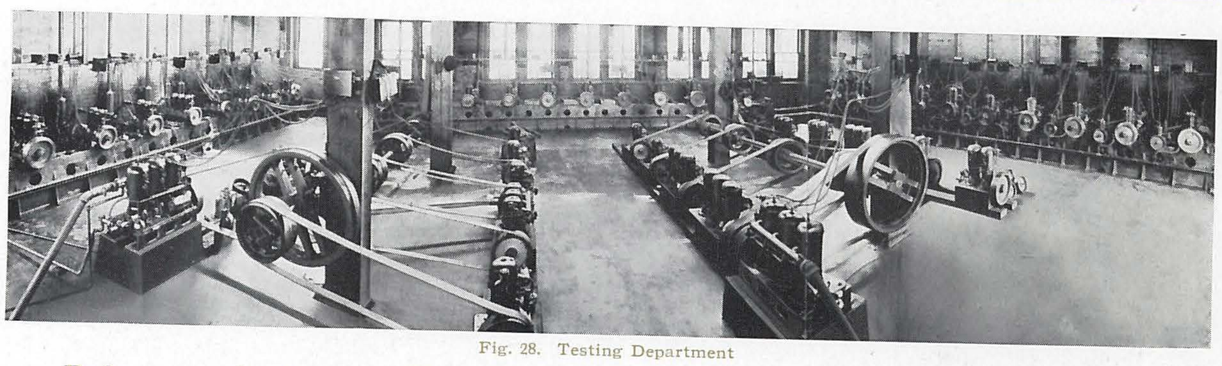


Fig. 28. Testing Department

Before completely assembling the carburetor it is necessary to carefully adjust the float feed valve, which operation is conducted with a device shown in Fig. 24. This adjustment of the cork float in its chamber is made with gasoline as in practical use, and when this operation is completed the carburetor is entirely put together and placed in position upon the motor. In the illustration (Fig. 25.) is shown the work of assembling the oil distributor, where all the finished parts of it are brought together and the distributor made ready to place upon the motor. At this bench the gauge glasses are all cut to size and placed in their proper receptacles. The oil valves are set in their positions, then packed and the connections for the brass tubes also fastened on. It is then put to a practical test with oil under pressure. At another bench the work of assembling the timer and its various parts is conducted. (Fig. 27) The timer gear is placed upon the fly wheel and its corresponding gear upon the timer shaft. These parts, thus completed, are passed on to the assembler who places them in their respective positions on the engine, first carefully adjusting and then permanently fastening them there.

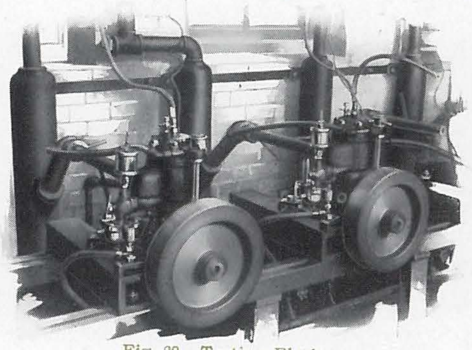


Fig. 29. Testing Blocks

Fig. 30

A specially constructed standard is shown in Fig. 26. to mount the motor during the work of assembling. It is so devised that the motor revolves upon the standard, which greatly facilitates the quick handling of the motor in assembling the smaller parts of the equipment.

Testing

From the assembling department we will now pass on to the testing room where the assembled motor is ready for its first test by being belted to a fast revolving line shaft. The purpose of this operation

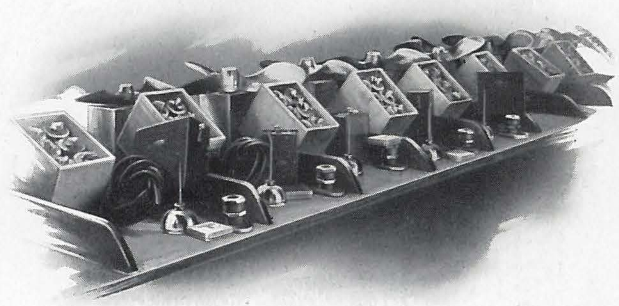
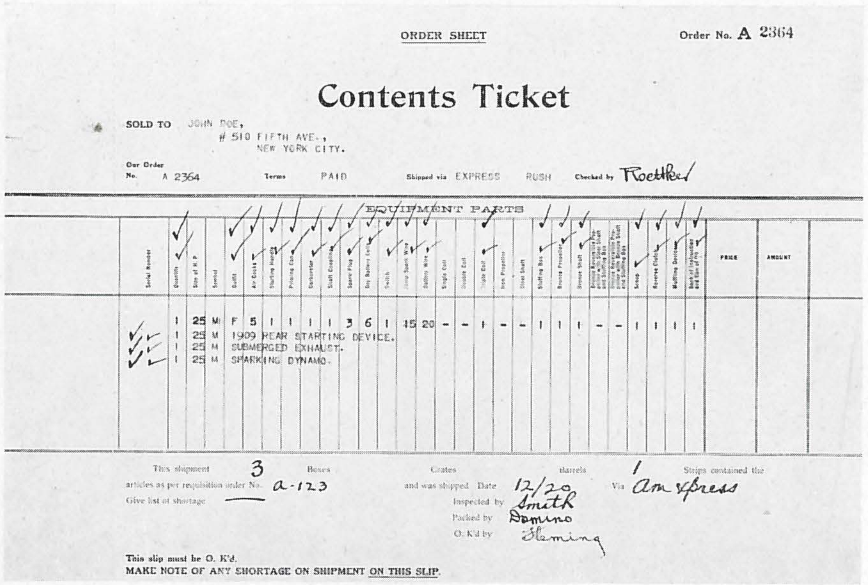


Fig. 31

or test is to give all bearings and working parts an opportunity to be worked in and to show that they operate freely, as well as to allow for the accurate adjustment of the bearings before putting the motor to its final operating test. Fig. 28 shows a portion of the Ferro testing room where several banks of motors are being given the test described above. The next step with the motor is placing it upon a testing block (Fig. 29.) where the water, gasoline, exhaust and electrical connections are made in the same practical manner as in the boat. In this condition the engine is set in operation under its own power and run for an indefinite time, until with properly adjusted gasoline mixture and its ignition outfit working in perfect order, the motor operates with uniform speed. With the further inspection and approval of this operation by the head tester, the motor is then put through a series of tests to determine the power it is capable of developing. If the motor in this final horse power test fails to develop more than a conservative increase above its rated power, it is given a rigid examination and then referred back to whatever department in which the defects may have originated. If however, it passes this test, it is ready for the cleaning department and its final painting, inspection, and preparation for shipment.



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EQUIPMENT PARTS

Serial Number	Quantity	Size of H.P.	Symbol	Outfit	Air Cocks	Starting Handle	Priming Cup	Carburetor	Shaft Coupling	Spark Plug	Dry Battery Cells	Switch	Jump Spark Wire	Battery Wire	Single Coil	Double Coil	Triple Coil	Iron Propeller	Steel Shaft	Stuffing Box	Bronze Propeller	Bronze Shaft	Bronze Reversible Propeller with Steel Shaft and Stuffing Box	Bronze Reversible Propeller with Bronze Shaft and Stuffing Box	Scoop	Reverse Clutch	Muffling Device	Book of Instructions	PRICE	AMOUNT
	1	25	M	F	5	1	1	1	1	3	6	1	15	20	-	-	1	-	-	1	1	1	-	-	1	1	1	1		
	1	25	M	1909 REAR STARTING DEVICE.																										
	1	25	M	SUBMERGED EXHAUST.																										
	1	25	M	SPARKING DYNAMO.																										

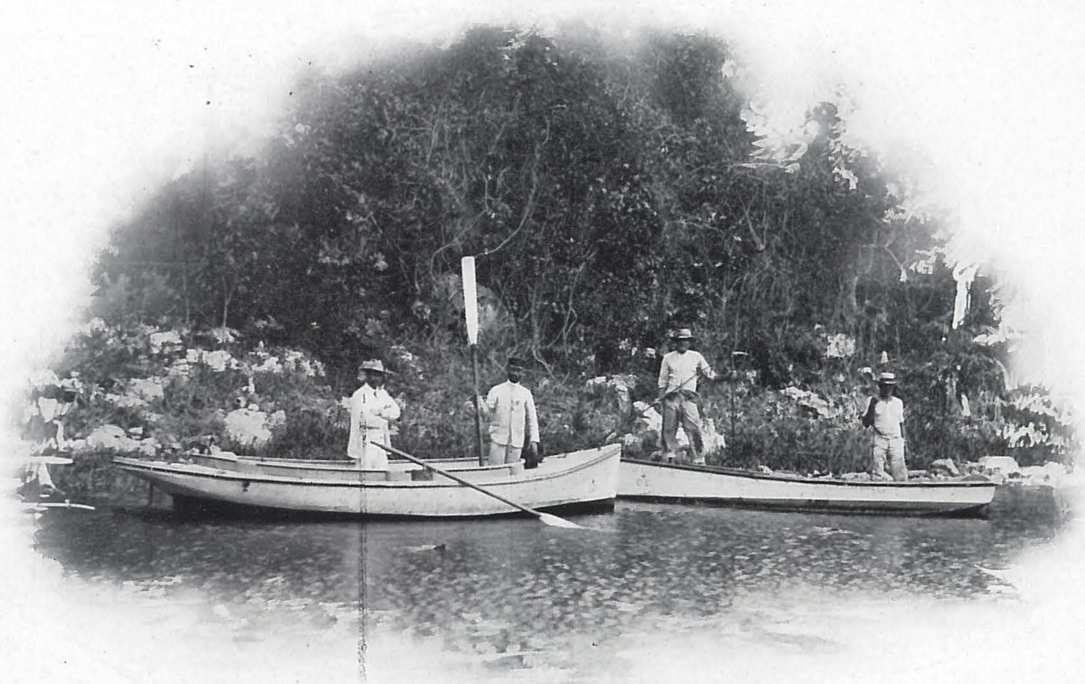
This shipment 3 Boxes Crates 1 Barrels Strips contained the articles as per requisition order No. a-123 and was shipped Date 12/20 Via Am Express
Give list of shortage ——
Inspected by Smith
Packed by Domino
O. K'd by Fleming

This slip must be O. K'd.
MAKE NOTE OF ANY SHORTAGE ON SHIPMENT ON THIS SLIP.

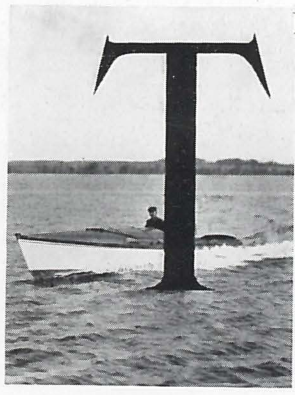
Fig. 32

The motor on entering the paint shop is carefully gone over for the purpose of removing any uneven surfaces and smoothing them down. Several priming coats are then given it, followed by a thorough rubbing with pumice stone, leaving a perfectly smooth surface over which the several finishing coats of color are placed. A final inspection is given the motor upon coming from the paint shop. The timer is thoroughly gone over, its adjustment examined and rectified, if necessary, the same being done with the carburetor and all other adjustable parts. As the inspector finishes each examination and adjustment he places a printed tag with diagrams and instructions on that part of the engine (Fig. 30.) for the guidance of the customer in operating it. To make certain of no loose joints or leaks in the oil system, it is finally put to an air pressure test. Thus, with these finishing touches and rigid inspection, the motor is turned over to the stock department, whence it goes finally to the shipping department.

A marine engine, although it appears small and compact, is comparatively heavy and must therefore be carefully boxed, particularly so, for long shipments. Fig. 30 shows shipping box for a motor and the substantial manner in which it is constructed. The illustration (Fig. 31.) will give the reader an idea of how an order is laid out in a separate bunk with all its items preparatory to boxing. Before packing any portion of the order, however, it is checked several times from the order sheet or contents ticket, (Fig. 32), by different inspectors in order to maintain absolute accuracy in the equipment before the engine leaves the factory.



Reverse Gear



THE advantages to be gained by installing a reverse gear are positive control of a forward and backward movement to the boat, and a neutral point. To be safe and thoroughly enjoyable or useful a power boat must be provided with a means of changing *positively* and *quickly* from full speed ahead to full speed astern. This is a point now being insisted upon by most racing rules. A reversing gear is a system of clutches and gears by means of which the propeller shaft may be made to turn either opposite, or in the same direction as the motor crank shaft. The reversing gear uses a solid propeller which unquestionably may be made stronger than a reversing propeller wheel, and can take more hard blows and knocks without breaking, but its great advantage is that it places the reversing mechanism inside the boat where it is less liable to meet with mishaps and is accessible for repair in case anything does happen.

There are countless instances where it is necessary to bring a boat to a quick stop, reverse or slow down, then go ahead, and to perform these operations repeatedly. When operating a boat in crowded waters or making a dock, the feeling that one has a reliable reverse gear coupled to the propeller shaft gives the wheelsman confidence in his craft, which is wholly lacking when his boat is not equipped properly for reversing.

Another feature in favor of a reverse gear equipment, just as important as the forward and backward control, if not more so, is the neutral point.

When the reverse gear is thrown into a neutral position the motor may be running, but this motion is not transmitted to the propeller, or in other words the motor may be going without the boat moving at all.

This is a very desirable point for the following reasons: First. If you wish for any reason to try out your motor to see how it is working, with a reverse gear equipment you may run your motor just as long and at any speed you wish without ever putting out from the boat house or landing, and without having lines out from bow and stern to hold the boat stationary.

Second. Oftentimes for various causes the boat is stopped for such a very short while, too short a time really to shut the motor down; with a reverse gear the motor may continue to run while the forward movement of the boat is stopped.

Third. And probably the very best reason of all for installing a reverse gear is *ease of starting*. By throwing the reversing gear into the neutral position, the effort required to turn over the fly wheel of the motor when starting is very greatly lessened. Without a reverse gear it is necessary when starting a motor to turn over not only the fly wheel and crank shaft of the motor, but the propeller shaft and propeller in the

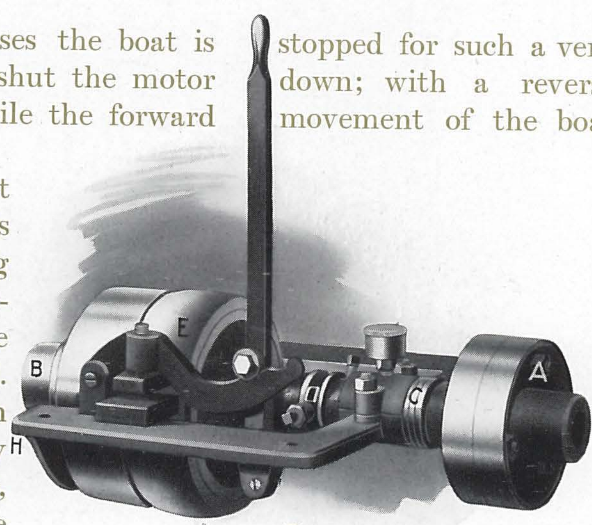


Fig. 1

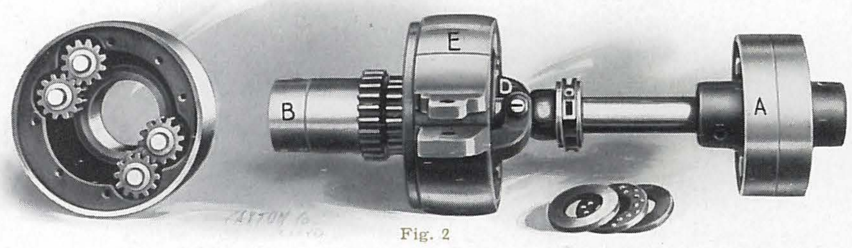


Fig. 2

water. When an automobile is started the engine alone is started first before taking up the load of operating the car.

This same idea is carried out in most machinery plants, that is, the load is not placed on the engine or motor until it is fairly started.

Why should it be otherwise in a boat especially when the motor used is of fairly large size?

The foregoing has demonstrated the advisability of installing a reverse gear. The question now to take up is the kind of gear to use.

Like all mechanical devices a poor reverse gear is very much worse than none at all.

Some of the points to demand in deciding on a reverse gear (whether you purchase a 1909 Ferro Reverse Gear or not) are the following:

The good reversing gear must couple the motor directly to the motor shaft on the forward drive; there should be no gears running, and the whole device should act simply as an extra fly wheel or a straight unbroken shaft. To carry the power through gearing on the forward drive is too wasteful and noisy to be considered for a moment. When the gear is in the neutral, the motor runs free, without turning the propeller shaft; it makes no difference whether the gears run or not, as there is no load on them and therefore no wear. On the reverse position, the gears come into play and the power of the motor is transmitted and reversed by them. The gears should be "in mesh" with the motor running. The changes from the neutral into the forward speed or from neutral into the reverse should be so arranged that the load is picked up gradually without a jerk. All brakes, clutches, and other parts should be easily adjusted and all gears should have bushings running on steel pins; the wear will then come on the bushings, which cost about one tenth the price of spur gears.

Gears should be of ample diameter, and stub tooth pattern.

The gears should be enclosed in an oil-tight case, which can be filled with oil or packed with grease as may be required.

The entire gear ought to have a rigid fore and after bearing.

Below is a brief description of the 1909 Ferro Reverse Gear:

In the manufacture of reverse gears, we have given great care and attention to the quality of material, simplicity of operation and adjustment. All bearing surfaces are extremely large, made of phosphor bronze, running on hard-

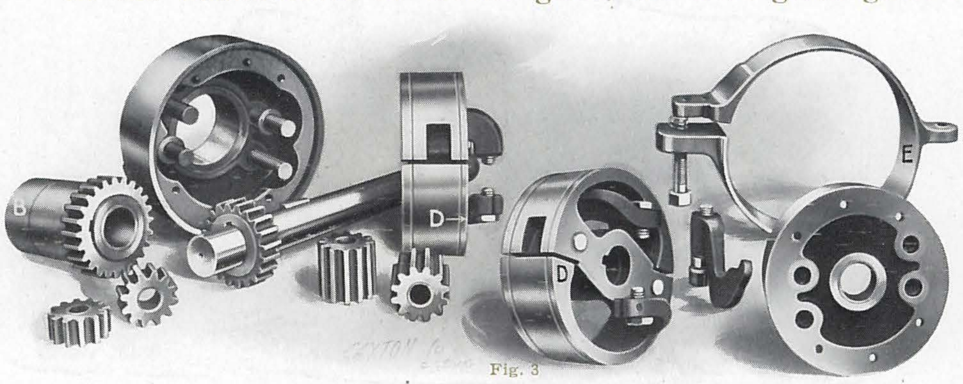


Fig. 3

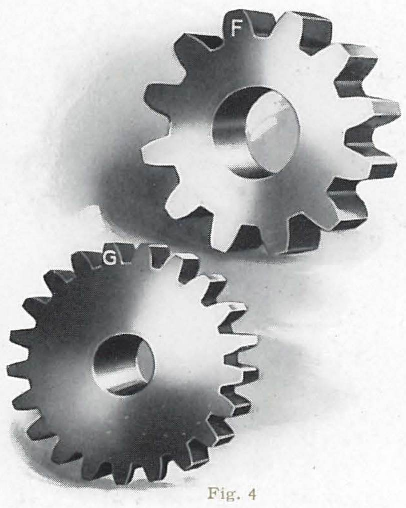


Fig. 4

ened steel shafts in an oil tight case. The leverage on this gear is such that the gear lever can be operated to reverse or go ahead with very little effort.

In the following description the letters refer to same parts in the different illustrations:

NOTE—The gear proper is a straight unbroken piece of hardened steel.

A—Flange coupling fitted to gear shaft. Fig. 5.

B—Hub of gear drive bored to fit engine crank shaft. This makes gear ready to install in boat without purchasing extra couplings or other parts.

C—Ball thrust bearing to relieve all end strains on gear or crank case.

Illustrations on page 49 show Ferro gear completely disassembled. All spur gear pinions are of high carbon steel, case-hardened.

The internal band D, Fig. 3, and the bronze external brake band, E, have extremely wide finished surfaces to avoid slippage, assuring positive drives in either direction and eliminating the necessity of frequent adjustment. There is absolutely no lost power or heating due to binding of these bands.

The gear teeth are of the stub tooth pattern which is conservatively estimated to be 33% stronger than the standard pitch gear.

F—Gear with stub teeth. G—A gear with standard pitch teeth. Fig. 4.

Judge for yourself from comparison how much stronger the stub tooth gear is than the standard pitch gear.

Every part is properly balanced before assembling and mounted on a frame that can be bolted directly to the 1909 Ferro crank case at H, which will insure perfect alignment. Fig. 5.

Where the Ferro Reverse Gear is to be used with some other motor than the 1909 Ferro, a different clutch frame is furnished, with fore and after bearings, than on the gear shown, so that the Ferro gear is adaptable to any motor built up to 25 horse power.

A complete catalogue is published describing the Ferro Reverse Gear. In addition to the detail construction of the gear, it explains the care and the operation of it and also gives full particulars as to how the clutch is designed and how to get the most serviceable results with it. This book is mailed to anyone upon application, who is interested in a reverse gear.

Sizes of Ferro Reverse Gears

No. 1, suitable for motors up to 5½ horse power.
No. 2, suitable for motors up to 12 horse power.
No. 3, suitable for motors up to 25 horse power.

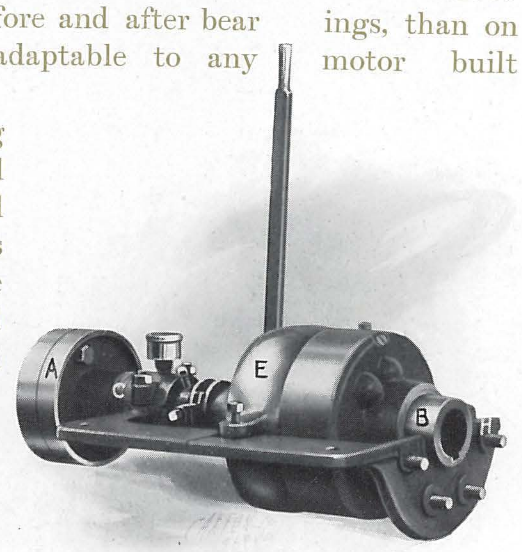
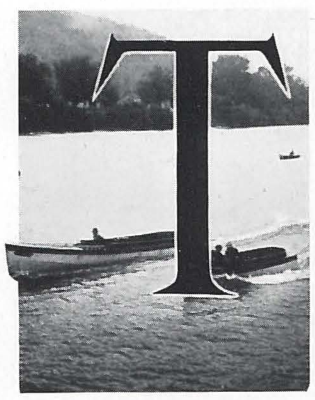
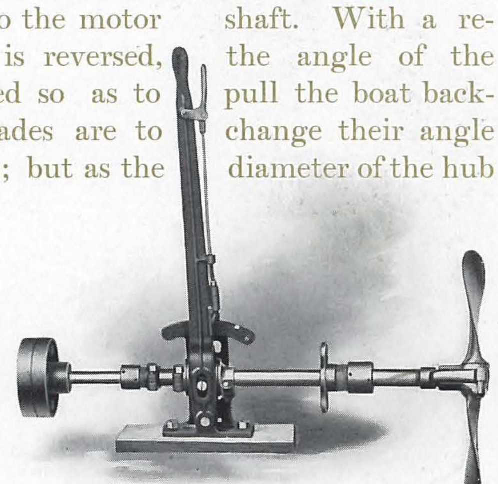


Fig. 5

Reversible Propeller

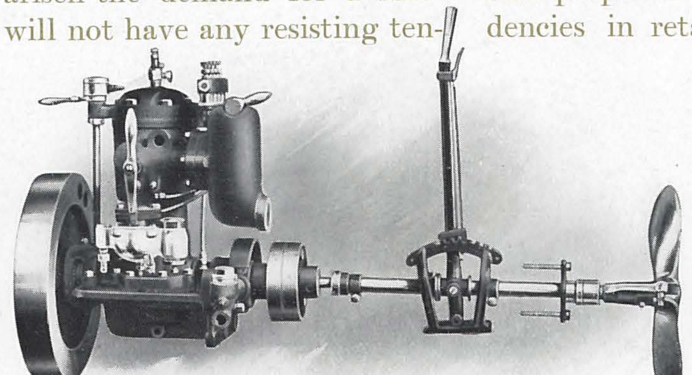


THERE are two methods, besides reversing the engine itself, that are used for reversing the direction of boats. One is the reverse gear, the other the reversible propeller. A reverse gear is shown on page 48. With a reverse gear, when it is reversed, the propeller shaft turns opposite to the motor shaft. With a reversible propeller, when it is reversed, the angle of the propeller blades is changed so as to pull the boat backward. If the propeller blades are to change their angle they must turn in the hub; but as the diameter of the hub of a motor boat wheel is small, it must be hollow to contain the device for shifting the blades and, if possible, it should present a smooth exterior. To fasten three blades, or even two, to the small hub, to get them so that they will turn easily when there is a pressure on them, to have no play and plenty of bearing surface to prevent wear, is not an easy matter, because there is so little room on the hub or inside of it. This fastening of blades to the hub is the vital point, the rest is easy. The usual method of construction is to make the propeller shaft in two parts. An inside, solid shaft, driven by the motor and keyed to the hub, and a hollow tube outside this shaft, which is shifted forward and aft by the lever inside the boat. The shaft terminates in the hub, in which the propeller blades are pivoted. The tube terminates in a yoke which engages a lug or pin on each blade, and serves to shift the angle or pitch of the blades, when the propeller is either idle or in operation, hence, giving the propeller a forward or reverse pitch. The great advantage of a reversible propeller is the splendid control you have over the speed of the boat, from practically nothing at all up to full speed in either direction. The angler who trolls with his launch finds the reverse propeller advantageous for maintaining a slow forward motion, which trolling requires. For similar purposes the reverse propeller has its merit.



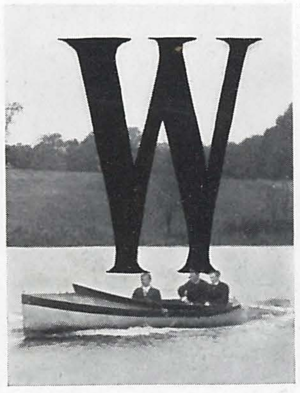
Reversible Propeller

With the advent of auxiliary power in the small and large sailboat, there has arisen the demand for a suitable propeller which, when the boat is under sail, will not have any resisting tendencies in retarding the forward motion of the boat. Several reversible propellers on the market are so designed that blades can be turned edgewise. It is termed a "feathering" blade. Where this type of reversible wheel is constructed to give the strength and serviceability that is required, and to withstand severe usage, it can be used to best advantage by the speed calculating yachtman.

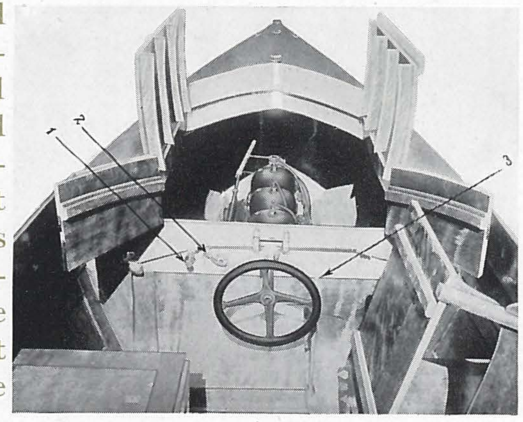


A Two-Blade Reversible Propeller Complete, Attached to Motor

Automobile Control

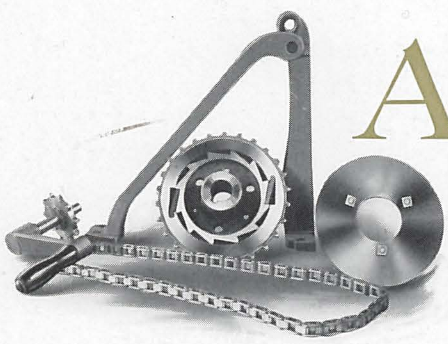


WITH the development of the racer and semi-speed boats a demand for a simple boat and engine control has arisen. The automobile control furnishes an illustration and it is in fact from this source that the auto boat derives its name. In a forward compartment with hinged covers, the motor is partitioned off under a hood and protected from weather and spray. From his seat directly aft of this compartment the operator has within his reach the steering wheel, timer and throttle control, priming or relief cock rod, also the reverse lever. From this same position he can without any undue exertion start his motor, reach the switch, adjust coil vibrators, also the lubrication.



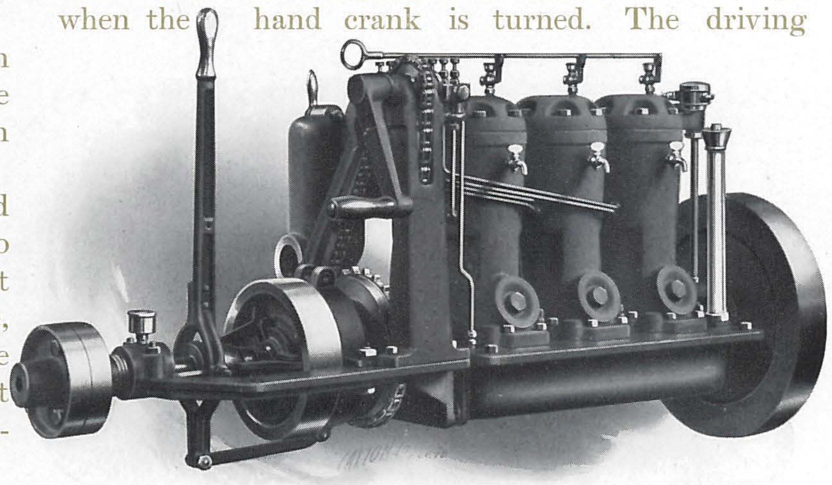
1, Relief-Cock Rod. 2, Timer and Throttle Levers. 3, Steering Wheel

Rear Starting Device



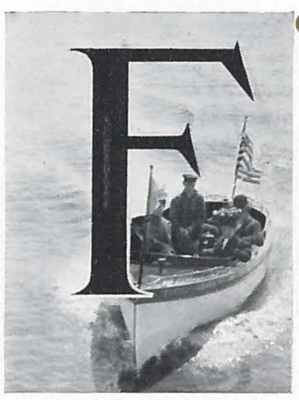
A DESIGN of starting device is illustrated herewith which is a successful development of careful study by our mechanical department and which is attachable to all Ferro motors and any others where their dimensions will permit. The body of the driven sprocket contains a ratchet movement that relieves the action of of both sprockets and chain when the motor starts; hence there is nothing in action with the device except when the hand crank is turned. The driving sprocket is mounted rigidly on steel supports from the engine bed and keeps the chain in perfect alignment.

When the motor is placed well forward as in the auto boat, for example, where it is difficult, if not impossible, to crank the motor at the fly wheel, the rear ratchet starting crank is virtually indespensable.



Mufflers

AIR MUFFLER

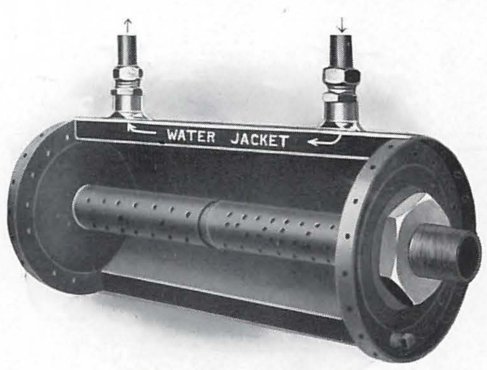


FOR a long time a device called an air muffler has been used to deaden the noise of the exhaust gases from a gasoline motor. This air muffler is usually made in the form of a cylindrical chamber attachable to the exhaust pipe. It is fitted inside with baffle plates, against which the exhaust gases expand, and then escape into the air at the open end by the way of an attached pipe leading through the side of the boat at a point above the water line.

A Common Form of Marine Air Muffler

WATER MUFFLERS

The air muffler serves its best purposes on automobiles. In boats, different conditions exist. On account of the well known condensing action of water and consequent reduction in pressure where cool water is mingled with the exhaust gases, it is possible to both silence the noise and increase the power developed by the engine. Besides, with the water being pumped through the cylinder jacket constantly, an automatic feed to the exhaust pipes may be had, keeping them almost cool to the touch.



A Common Form of Marine Water Muffler

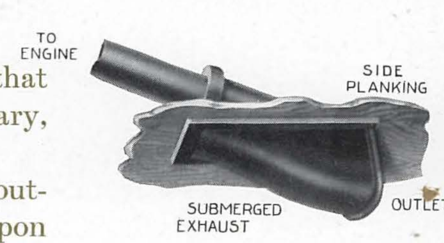
The first form of muffler consisted of a water jacket around an air muffler through which the waste cooling water was led and then piped overboard.

Then another method was tried, namely, running some of the water directly into the exhaust pipe, between the engine and the muffler. In this case it was necessary to make the muffler water-tight, while the air muffler is not water-tight. The immediate result was a great reduction of noise and pressure in the exhaust. It required careful regulation of the water, also a drain for deposited water in the muffler.

The Under-Water Exhaust

The under-water or submerged exhaust is an effective way of muffling the exhaust noises, but it must be installed properly to be a success.

A submerged exhaust should never be put in a boat without a relief valve leading to a free opening, so that when starting, or at any time that it may be necessary, the exhaust may be turned out into the open air.



Ferro Submerged Exhaust

The depth below the water and the location of the outlet on the bottom of the hull is dependent greatly upon the general lines of the boat.

Propeller Wheels

IN speaking of propellers the terms *diameter* and *pitch* are used. The diameter of a propeller is a quantity which can be easily measured. The meaning of the phrase *pitch of a propeller* is not so well known to the novice. The action of a propeller may be compared to an ordinary bolt being screwed through a nut. Each time the bolt is turned once around it travels a certain distance through the nut. If the angle of the threads of the bolt is made greater or less at each turn, the bolt will travel a greater or less distance through the nut as the case may be. The blades of a propeller are twisted so as to cause the same action as the threads of the bolt. Therefore, the distance the propeller advances at each revolution is dependent on the angle of the blades. For example, a propeller blade may be designed so that at each revolution, if the blades of the propeller followed their own angle without any lost motion (just as the bolt does when being turned in the nut), it would advance 20 inches. This propeller then is called a 20-inch pitch propeller.

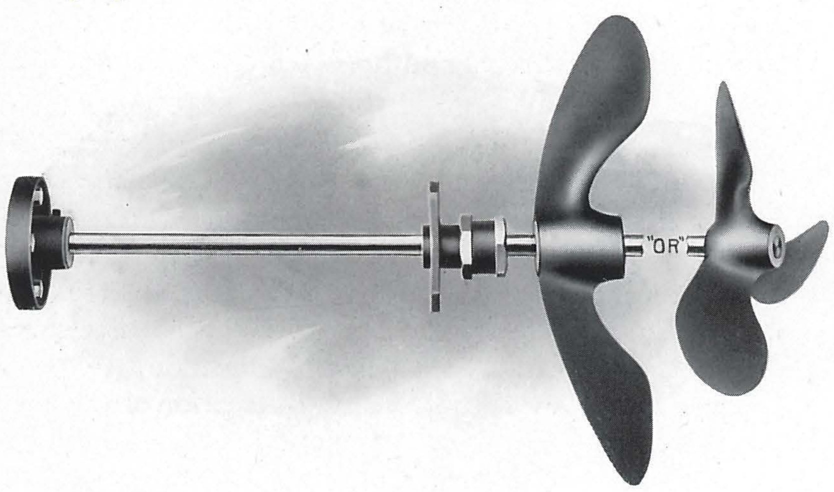
A 20-inch pitch propeller does not mean however a propeller that advances 20 inches in the water each time the propeller is turned around, for while the angle of the blades may be set to advance 20 inches at each revolution, still the propeller is turning in water, a liquid, not like the bolt turning in the nut, a solid; consequently there is a loss.

As this 20-inch pitch propeller turns over, it throws some water back and away from it so that in one revolution this propeller might advance 15 inches. The loss of 5 inches or 25 per cent. is called slippage.

It is desirable, of course, with every power boat to get this slippage down just as low as possible.

The hull, speed of motor, and propeller must all be considered jointly in order to get the slippage down to a reasonable point, and as these conditions all differ so much in practically every case, it is always advisable to consult the designer or builder of your boat if possible on the subject of propulsion.

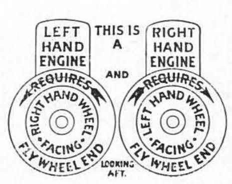
One common mistake in motor boat design is that of giving considerable rake, angle or slope to the propeller shaft. This is especially harmful with a boat and outfit which requires a wheel of low pitch ratio; with high ratios it is not so bad but is still objectionable. Besides causing a waste of power, because the propeller thrust is not in



line with the resistance of the hull, it increases vibration. In extreme cases the blades which are coming up toward the surface may be trying to back the boat and the descending blades must not only overcome the hull resistance, but this backing tendency as well. It cannot be impressed too strongly upon you the undesirability of having an excessive rake to the shaft. Never allow it to run over ten degrees at the most, and five degrees is the limit for good design.

With regards to two-bladed and three-bladed wheels, there is not much difference in their efficiency if the wheels are suited to the motor and hull. An owner or builder may have a boat with an unsuitable three-bladed wheel; if he happens to replace this with a suitable two-bladed wheel, the boat's speed may be materially increased, and that man is rather apt to be an enthusiastic convert to two-bladed wheels. He does not stop to consider that the comparison is manifestly unfair to the three-bladed type and proves nothing at all except that for his particular outfit the two-bladed wheel used was better than the three-bladed one. Three-bladed wheels are supposed to have better balance than two-bladed ones and are more generally used on that account. As a matter of interest it may be noticed that one of the most progressive and successful concerns in this country uses two-bladed wheels on most of their outfits because they say the results obtained are better.

How to tell a Right-Hand from a Left-Hand Wheel

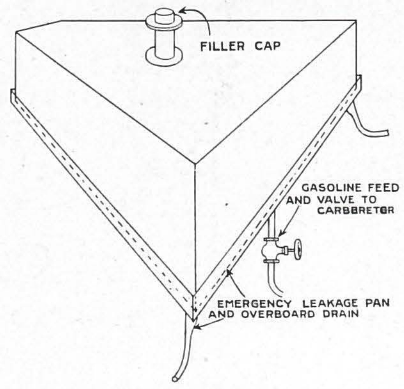


In facing the fly wheel looking aft, if top of fly wheel turns from right to left, it requires a right hand wheel. If top of fly wheel turns from the left to the right, a left-hand wheel. (Note line drawings.)

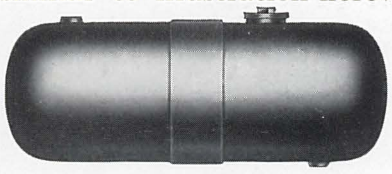
In standing aft of stern end of boat, facing the bow, a right-hand wheel enters the water turning to the right (to drive the boat ahead), the same as a right-hand screw. A left-hand wheel enters the water turning to the left, the same as a left hand screw, taking the water on the after side of the blades or flat side. The crowning side of wheel should be next to boat, the flat side or working surface aft.

Gasoline Tanks

SPECIAL care and attention should be given to the gasoline tank and its connections to the motor. Gasoline itself is harmless with fire, but is a volatile substance and in contact with air generates a highly combustible gas. It is evident that a gasoline tank and its piping to the motor should be made permanently free from possibilities of leaking. Tanks are commonly made of heavy galvanized sheet metal, also sheet copper riveted and soldered together. The chances for leaky seams are largely possible, hence we recommend, where convenient to install, a seamless steel or copper tank similar to illustration herewith. Another type of tank is the square or V shape tank made to conform to the lines of the boat in which it is installed. The bottom of the tank should be at least five or six inches higher than the carburetor, so as to form a gravity feed to it through a copper or lead pipe of no less than a ¼ inch inside diameter. The tank should be rigidly fastened to prevent the rolling or pitching of the boat dislodging it.

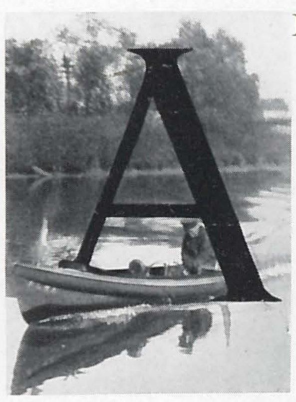


V Shape Tank



Seamless Cylindrical Tank

Thrust Bearings



A PROPELLER wheel turning in the water exerts an inward thrust on its shaft when driving a boat ahead, and an outward thrust or pull when the boat is moving astern with the reverse motion of the propeller. It is customary for engine builders to provide for this thrust somewhere on the motor, otherwise it would be necessary to place a special thrust bearing along the propeller shaft. The pressure brought to bear upon a thrust bearing is no mean one and it is therefore necessary to reduce the friction of it by using either roller or ball bearings. In the illustration Fig. 1, is shown the ball thrust bearing which is the simplest in construction and serves the purpose most satisfactorily. The steel balls are set in a brass ring or cage, and when the bearing is set up the hard steel rings or discs come flat against the balls upon which they turn with the least amount of friction.

On the Ferro motor two sets of these ball thrust bearings are used to take both the forward and reverse thrust of the propeller and are so placed that through them the thrust is transmitted to the frame of the motor and not to any of the working parts. Moreover they are placed where they are readily accessible for adjustment or repair.

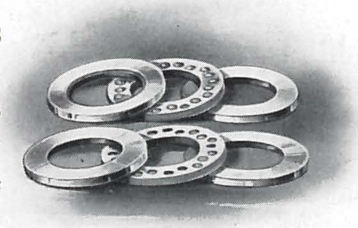
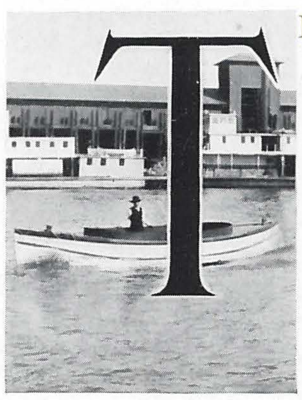


Fig. 1.

The Problem of Gasoline Engine Power for Heavy Marine Work



THE Gasoline Engine is unquestionably a practical success for work boats. As a proof of this statement, take the salmon fleet of the Fraser and Columbia Rivers and Puget Sound; the power boats plying the waters of San Francisco Bay, Terminal Island and San Diego Bay of the California Coast; the bateaux of the Gulf and skip jacks of Florida; the skiffs, smacks and dories of the Atlantic Coast, including the bug eyes and canoes of Chesapeake Bay. All these types together with hundreds of other styles of hulls used on the Great Lakes and Island waters were a few years ago propelled by oars and sails. This same condition exists abroad. Although the installation of gasoline power in work boats was started but a few years ago, it is a remarkable fact that today the majority of these boats are equipped with gasoline engines.

Therefore, it is not a question whether the gasoline engine is practical for work boats, but *the point to learn is what particular type of gasoline engine is best adapted to the different kinds of work boats.*

It is frequently stated that an engine, to be satisfactory for work boat use, must turn at a low rate of speed. Such is not the case.

The explanation as to why the opinion in favor of low speed motors for work boats has existed, is due to the following:

The four-cycle engine has been under the course of development for many years, while the present two-cycle engine is the development of but the last few years.

The four-cycle marine engine is generally of the heavy slow speed type.

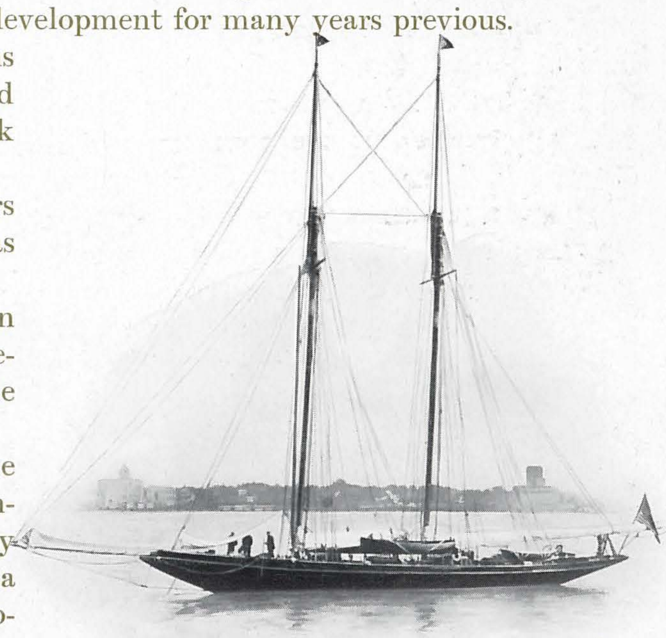
Naturally a few years ago when the two-cycle motor was first placed on the market in an experimental stage, it suffered when compared with the heavier four-cycle motor that had been undergoing development for many years previous.

This state of affairs for a few seasons gave rise to the belief that a slow speed motor was more satisfactory for a work boat.

Within the past four or five years the history of the two-cycle motor has changed.

The two-cycle motor is no longer in the experimental stage, but is today developed and improved to a remarkable degree of efficiency.

The result of this development of the two-cycle motor is that people are learning that work boats are more effectively powered if the motor turns up at a reasonably high rate of speed with a propeller of correspondingly lighter pitch.



A Modern Auxiliary Schooner Yacht Equipped with Gasoline Motor.

When a purchaser is about to decide upon a work boat, in coming to a decision the following points should be considered:

First, the initial cost—Second, weight of motor required—Third, durability—Fourth, fuel consumption—Fifth, propulsion—Sixth, ignition.

Each of these points will be taken up in turn with the idea of placing these features before the prospective buyer so that he may judge more intelligently as to his own individual requirements.

I. Initial Cost

Initial cost is the first point to be taken up.

One buyer will say he wants nothing but the engine he can get for the least money. It is very probable this man will pay more for his motor in the end than if he would have looked further than the price alone.

The less conservative buyer sometimes gains the impression if he buys the engine selling for the highest price on the market that he is getting the best. This buyer usually spends a great deal more money for initial cost than is necessary to obtain the same or better results.

From this is shown that initial cost or price of the motor ought not to be the deciding element. The points to look for on this subject are the design of the engine, the materials used and the responsibility of the manufacturer—all very important.

A satisfactory motor, considering these points, will probably sell not at the lowest or the highest price, but at a reasonable figure.

II. The Weight

The weight is the next feature for the prospect to take up.

When considering the point of weight alone, the most reasonable thing in the world to say is—place in your boat the lightest possible engine that will perform your work properly.

If you require a great deal of weight in your hull, don't buy an engine heavier than necessary in order to ballast the boat, for in doing this you are paying engine price for ballast.

Get your engine heavy enough to do your work, and if you need more ballast get old iron, lead, rock or any other heavy substance that is easily obtained, which for ballast alone answers the purpose as well as an engine and is decidedly more economical.

This brings up the question of different weight engines performing the same work.

You may get a motor that will develop its maximum power at a low rate of speed, and a motor of the same maximum power but turning at a higher rate of speed.

For instance, a motor of a certain bore and stroke turning at 400 R. P. M., develops a maximum of 10 horse-power, and another motor of a certain bore and stroke turning at 800 R. P. M., develops a maximum of 10 horse-power.

In other words, the slower motor at one impulse or stroke develops as much power as the faster motor does in two strokes, but as the faster motor makes two strokes to every one stroke of the other motor, it is evident that

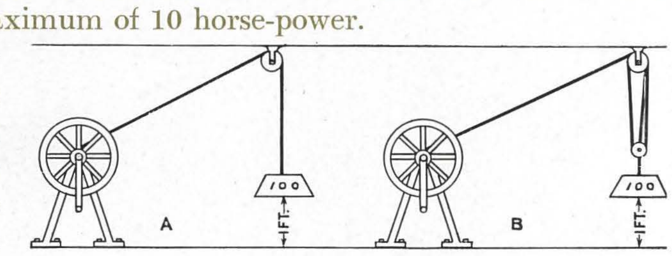


Fig 2.

they both develop the same power in the same length of time. As a further example of this development of the same power at different speeds notice Figure 2.

A is a hoist, which by one turn of the handle lifts the weight of 100 lbs. one foot.

B is a hoist rigged with block and tackle which requires two turns of the handle to lift the weight 100 lbs. one foot. It is obvious, if each of these weights are lifted one foot in the same length of time, that the same amount of work has been performed. However, in the case of B, which required two turns of the handle to lift the 100 lbs. one foot, the strain is divided and it therefore requires but half the effort to turn handle of B one time around as it does to turn handle of A.

This may assist in making it clear why a motor of a smaller bore and stroke going at a higher speed can develop the same power as a motor of larger bore and stroke going at slow speed.

Let us compare this slow speed engine and high speed engine of the same power.

The slow speed engine must develop at one revolution the same power the high speed motor develops at two revolutions, or one stroke of the slow speed motor must be twice as powerful as one stroke of the faster motor, all conditions being equal, the same power being distributed in two strokes instead of being contained in one.

To make the stroke of the slower motor more powerful, the piston displacement must be larger, which results in the various parts of the motor being proportionately increased in size and weight.

Therefore, a motor to develop the same power at a slower speea must do so at the expense of increasing the weight.

III. Durability

The next thing to consider in detail is durability.

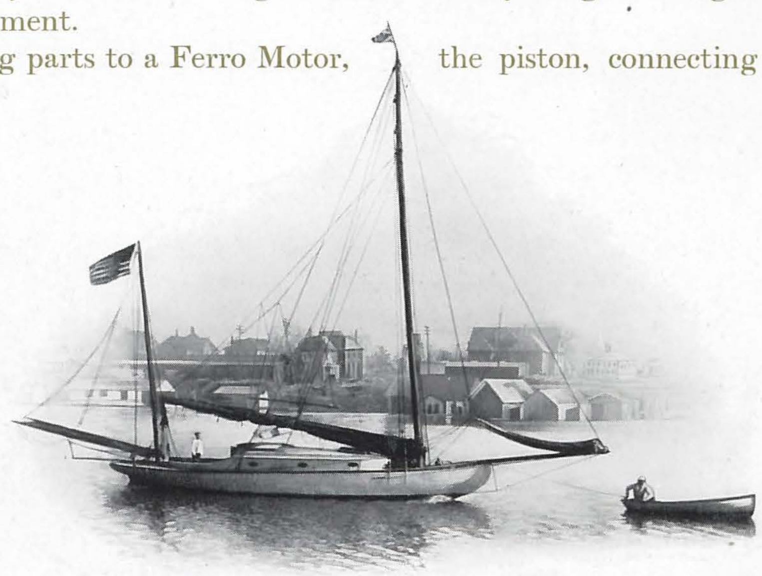
Does the fact alone that an engine is heavier mean that it is more durable?

The weight alone does not make the working parts of a motor lasting unless this weight is proportioned correctly and all bearings are sufficiently large. Weight improperly distributed is a detriment.

There are only three moving parts to a Ferro Motor, the piston, connecting rod and crank shaft.

With the weight and bearing surfaces of these parts proportioned correctly for the maximum speed of the motor, there is no more wear on a high speed engine than there is on any correctly designed piece of machinery, whether operated at a high or low rate of speed.

Another thing to bear in mind when comparing a high speed motor with a low speed



A Yawl being towed by its Motor driven tender

motor is the actual piston travel of each engine. The result is usually quite different from that expected. For example, the piston of an engine with an 8 inch stroke turning at 400 R. P. M., actually travels 3200 inches per minute. While the piston of an engine with a 4 inch stroke turning 800 R. P. M., travels 3200 inches per minute.

Again, we call your attention to any electric plant in the country. There you will see electric generators being driven at an exceedingly high rate of speed, yet their bearings do not necessarily have to be refitted any oftener than a slower moving machine. Why? Because the generator is designed to be operated at high speed. The bearings are properly proportioned and the lubricating system is effective.

To learn whether the bearing surfaces are correct and lubricating system effective on Ferro motors, your attention is called to page 22.

Therefore, it is unreasonable to say a motor is not durable because it is not *exceedingly heavy*. When properly designed, a light weight motor may be more durable.

IV. Fuel Consumption

Under this heading three subjects are to be considered:

First, the fuel or gasoline—Second, the efficiency of motor—Third, the amount of work to be performed.

The gasoline is the source of power. A given amount of gasoline when properly mixed with air will produce a specific amount of power.

Therefore, the gasoline engine is nothing more or less than a mechanical device to utilize the power contained in the gasoline.

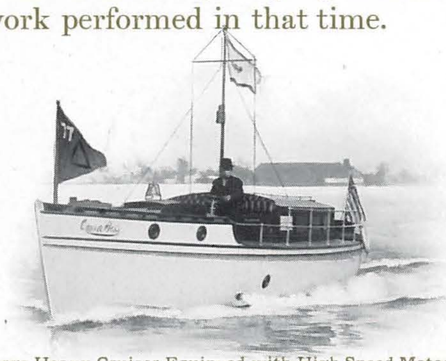
This being the case, the properly constructed engine of a given bore and stroke, economically utilizing the greatest amount of gas, is the most efficient.

Note: The motor must properly utilize the gasoline consumed, for any excess of gasoline used is not only a waste of fuel or power, but always cuts down the efficiency and speed of the motor.

Therefore, when considering the effectiveness of a motor, do so by keeping in mind not only the fuel consumed in a certain time but the work performed in that time.

For example, say it is 5 miles from A to B. An engine in boat called C makes this distance of 5 miles in 30 minutes and burns 10 pints of gasoline. On the other hand a motor called D under the same conditions makes this distance of five miles in 20 minutes but still burns 10 pints of gasoline.

This means motor D burned as much gasoline in 20 minutes as motor C burned in 30 minutes, but both motors went 5 miles or performed the same



Large Heavy Cruiser Equipped with High Speed Motor

amount of work. Therefore the fuel consumption on motor D is greater, yet it is the more efficient engine, for motor D can convert the same power from the same amount of gasoline in less time than C.

Hence on the consumption of fuel this point is to be remembered: A given quantity of gasoline contains a specific amount of power, and the most efficient motor is the one that can perform the greatest amount of work with this quantity of gasoline in a given time.

As has been seen in Fig. 1, the same amount of horse-power may be developed by a high speed motor as by a low speed, therefore as far as efficiency is concerned a high speed motor is at least just as effective as a low speed motor.

The foregoing demonstrates that *the bore and stroke or weight are not the only factors to be considered; to secure an effective motor, look to the design, to the materials used, and to the construction, for therein lie the secret of power and economy.*

V. Propulsion

After having taken up the subject of the power in the boat, the next point to investigate is whether the high pitch wheel (explanation of pitch, page 54) is more effective than the lower pitch wheel revolving at a higher rate of speed.

To assist in explaining this idea refer to Fig. 3, 4, and 5 through the following article.

Fig. 3 represents three different propellers revolving in the water.

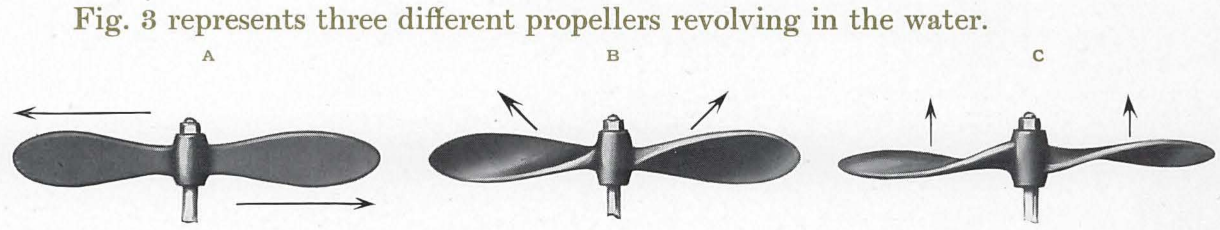


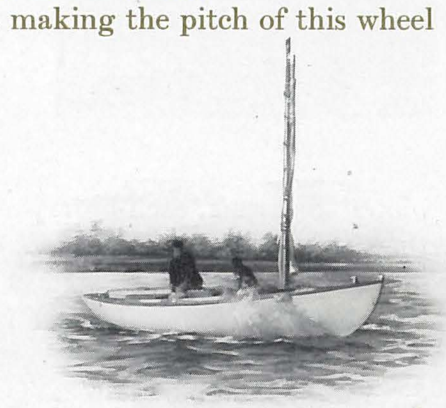
Fig. 3

A is a propeller with the blades set at the greatest possible pitch. That is, the blades are perfectly flat, and strike the water squarely with full surface of the blades. When a wheel of this description is revolved in the water, it throws the water straight out at right angles from the propeller shaft in the direction of the arrows. It is evident that this wheel has no tendency to move forward in the water.

B shows a propeller with the blades turned a little, making the pitch of this wheel a little less than A.

With this twist to the blades in propeller B, it is impossible for this wheel when revolving to throw off water at right angles the same as A. This propeller B would throw off in the direction of the arrows marked on B. Note this angle is not as great as A.

C is a propeller with blades twisted to almost the opposite of A, or in other words, the pitch has been made very low. Naturally as the pitch of C is so different from that of A, the water thrown off from C will



Heavy Fish Boat Equipped with High Speed Make-and-Break Motor

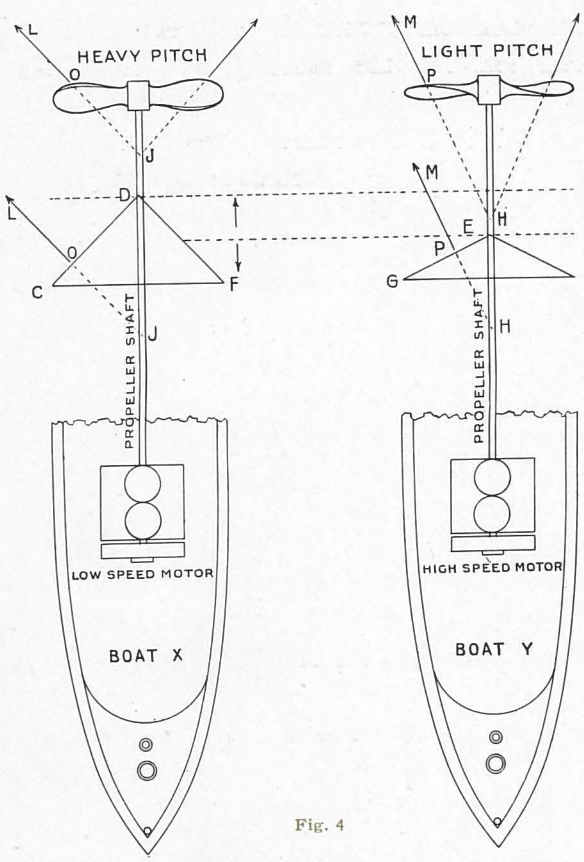


Fig. 4

be in quite a different direction to A. The angle or pitch of blades of C being very small, the tendency is to throw the water almost straight back.

The idea now is to show just what propelling force the wheels of different pitches exert on propeller shaft.

Kindly refer to Fig. 4, which shows a plan of boat with slow speed motor and boat with high speed motor. Both engines are of same power.

Propeller of Boat X turns over once in same time propeller of Boat Y turns over twice. Pitch on propeller D is twice as great as propeller E.

As propeller D advances or screws its way through twice the distance at one revolution that the propeller E does, it means that the blades of propeller D are set at a greater angle to the propeller shaft than the blades of E.

The line D C as compared to E G shows positions or angle of the blades of the propellers.

The line O L represents the direction of water thrown away from propeller blade D.

The line P M represents the direction of water thrown from propeller E.

To get the line of thrust or forward pushing force on the propeller shaft, extend the line L O and P M to propeller shaft. At J you see at what angle the line of thrust from higher pitch propeller hits propeller shaft, and at H is seen the angle at which the line of thrust strikes propeller shaft from lighter pitch wheel.

It is evident that a thrust in the direction P H is more effective in sending the boat ahead than a thrust in the direction of O J.

The fact that propeller E must revolve twice to attain same distance as propeller D, does not detract from this greater efficiency of low pitch wheel with high speed engine.

See Fig. 5. A is a nail hit by a hammer at the same angle as represented by the line of thrust O J in Fig. 4. B is a nail hit by a hammer at same angle as represented by line of thrust P H. A represents the high pitch and B the low pitch wheel of Fig. 4.

One hard blow is struck with hammer A at angle shown, and with hammer B two blows are struck, each blow just half as hard as blow struck by hammer A. Under these circumstances the nail A and the nail B should be driven in the same distance, for while two blows are struck on B to one on A, still each blow at B was but half as hard. As a matter of fact, the nail B under the conditions cited above is driven farther for this reason: While the force exerted on both nails was the same, the direction of the blows on B was more nearly in a straight line with the direction in which the nail is to be driven. Consequently the same force drives the nail deeper and

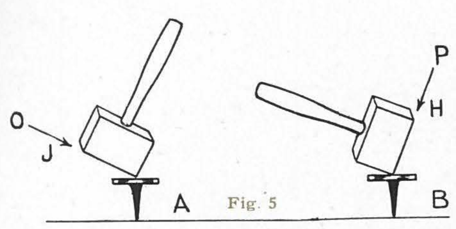


Fig. 5

the blow at the smallest angle is the more effective. This same theory applies to the line of thrust on the propeller shaft. The same engine power may be used, but if the line of thrust is near a straight line with the direction in which the boat is to go, the same effect will send the boat farther.

This means that a high speed motor with a low pitch will produce more effective work with a given quantity of gasoline than a low speed motor with high pitch, other conditions being equal.

Overburdening and Cavitation are two points that come up in discussing the subject of propulsion.

Overburdening is caused by using a propeller of either too great a diameter or pitch, either of which will cut down the speed and consequently the power of the motor.

Cavitation is commonly called churning up the water, and may be caused by using a propeller either too small in diameter or of too light a pitch, which would allow the wheel to turn at an excessive number of revolutions.

As shown in Fig. 4, the best practice is to equip an engine with a propeller of such design as to develop a maximum power. The diameter and pitch must be porportioned to the speed of the boat.

In selecting a propeller for a boat, the speed required is the first consideration.

A light speed hull will require a different propeller than a heavier lined hull, although both boats are equipped with the same power.

The propeller in each case should produce the same resistance on the engines.

However, it stands to reason that the same resistance on the engine of a light fine lined hull will send it farther through the water than the same resistance would a heavy hull. Therefore, the pitch of the propeller on the light hull must be greater to take advantage of the lightness of the hull, and on the wheel of the heavy hull the pitch or diameter must be less, thus permitting the engine to develop its maximum power.

When a Heavy Duty Make and Break Ferro Motor is ordered, a propeller of different diameter and pitch is furnished from the wheel furnished with the regular Ferro Jump Spark Motors.

VI. Ignition

For a description of the Ferro Jump Spark electrical equipment, see page 14, and for a description of the Ferro Heavy Duty Make and Break equipment, see page 15.

It is true that when installed with but very ordinary care, there is no more effective ignition system than the Jump Spark.

In making provisions for the actual work boat trade, it is far more satisfactory to base your plans principally from actual experience rather than to rely wholly upon theory.

The nature of the construction and operation of the jump spark system is such that it requires to be protected better from weather and water, especially salt water, than the make and break system, and this fact leads to a recommendation of

the Heavy Duty Make and Break Ferro for boats of the work boat type. For example, some fishermen are located on the open coast. Their boats are of the open type and oftentimes after a hard day the boat is beached and not even a piece of tarpaulin thrown over the engine.

In other boats, fish or oysters are piled all about the engine and ignition system.

These conditions are two of many adverse circumstances under which a work boat must operate day in and day out.

Naturally the demand among work boats has grown for an ignition system that requires the least protection from this abuse and weather.

Therefore, on account of this demand the heavy duty Ferro motor is equipped with the Make and Break Ignition System. The heavy duty Make and Break Ferro is also equipped with a heavier fly wheel thus permitting the motor to handle a propeller of larger diameter and correspondingly lighter pitch *without any added vibration*, for as explained before in this article, a propeller of this type is more suitable for the work boat.

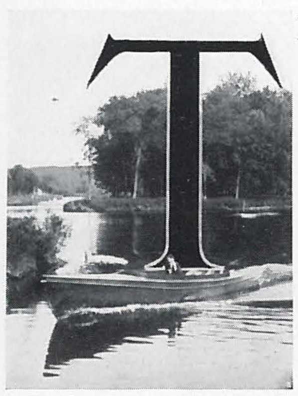
Conclusion. In this chapter the idea has been to place before the reader the reasons why a motor of normally high speed should be placed in ordinary work boats.

No attempt has been made to go into detail and make this article of such a technical nature as to be only understood by naval architects and other men exceptionally well versed in the motor boat line.

The intention has been to make this chapter applicable to the ordinary prospective buyer. The average buyer as a rule has his own particular business to attend to and naturally is unable to give the theory of the workings of marine gas engines and motor boats any considerable time or thought.

Such being the case our aim was to show, by using ordinary terms and examples, that the statements made are grounded on facts, and that no matter how deeply you may delve into the subjects, the conclusions eventually arrived at will coincide with those of this particular article.

The Adaptability of the Ferro Motor for Stationary Use

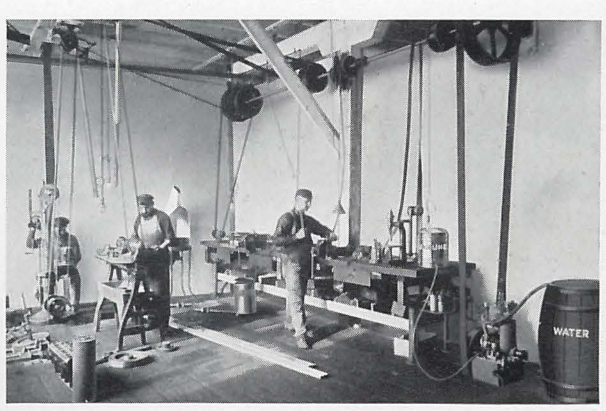


THE statements contained in this article as to the effectiveness of Ferro motors for stationary use are not based on theory. During the years in which Ferro motors have been shipped out to all parts of the globe much interesting information on this subject has reached the Cleveland office through the mail and Ferro traveling salesmen. A Ferro salesman from the home office wrote in one time from a small town in the state of Oregon, saying he had just read the town paper which was printed on a press operated by a 3½ H. P. Ferro. The same man when going west sold a number of 5½ horse-power Ferros in Nevada to work dry placer machines out in the deserts. From Taganrog, Russia, a Ferro agent sent in photograph of a Ferro motor running an electric generator giving light for a moving picture outfit.

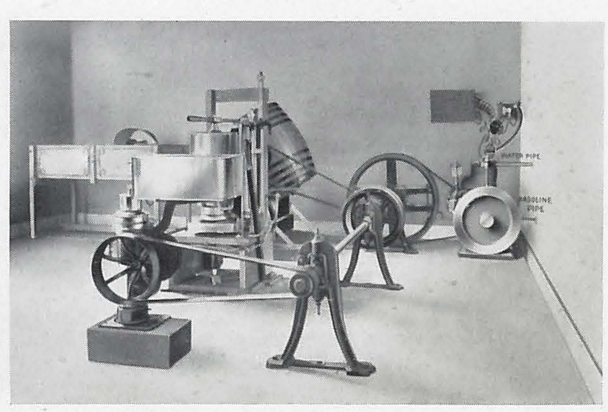
The Ferro representative at Melbourne, Australia, wrote "You will be glad to know that we have lately sold your engines to drive such widely different plants as chaff cutters, rock crushers, sewing machines, centrifugal pumps, printing presses, coach builders wood working machinery and of course, launches." Thus the files at the Cleveland office continue to record the subject of Ferro motors used for stationary purposes.

To any one who has given the subject any thought it is evident that the work required in turning a propeller around at a certain speed in the water for all practical purposes does not vary. A marine motor is therefore built to operate most satisfactorily when the work to be performed is constant. Under such conditions the carburetor and timer of a motor can be set at a certain point and the engine needs no further attention from the operator except to watch the lubrication.

There are innumerable cases of stationary work where the load is an even one, and under these circumstances a motor of the Ferro type, although not equipped with an automatic governor, will prove perfectly satisfactory. The advantages of the Ferro Special and regular Ferro motors for work of this constant load type are many.



Small Machine Shop Operated with a 4 H. P. Ferro



4 H. P. Ferro as Applied in the Dairy

The simplicity of Ferro motors is an appreciable feature, for in most cases the engine is not operated by an expert mechanic. The lubricating system is a very important one and after reading a detailed description of this positive pressure feed, it may be clearly seen that this method of oiling the motor is most effective.

The motors will develop their full rated horse-power with proper application.

A Ferro motor for stationary purposes requires only the motor and ignition equipment which is called outfit C and a pulley of proper diameter to place on crank shaft. Also a tank necessary to hold water for cooling purposes. The pulley and tank are not included in outfit C. One can usually obtain these in his own vicinity. However, a purchaser may order the pulley from the Ferro Machine & Foundry Co.

To determine what size pulley to place on a motor, the following method of calculation may be of some assistance to some purchasers:

Multiply the circumference, in inches, of the driven pulley on the machine by the number of revolutions this pulley must revolve per minute, or R. P. M. Divide this product by the number of revolutions at which the motor must operate to develop its rated power. The quotient thus obtained is the circumference, in inches, of the pulley, which divided by 3.1416 will give the diameter of the pulley required to be placed on the motor. When ordering a pulley, first state the kind you desire then give the diameter and the width of the face or rim of the pulley. Also state the diameter of shaft on which pulley is to be placed.

The R. P. M. and diameter of crank shaft of each size motor is given on the specification sheet and from this information can be figured just what size pulley is required to be placed on the crank shaft.

Where a low speed of driven machinery is required, it sometimes becomes necessary to belt first to a countershaft.

It is quite out of the question to enumerate all the different kinds of stationary work to which the Ferro motor is adapted, but wherever the work to be performed is of a fairly constant load, experience has proven that the Ferro will give entire satisfaction.

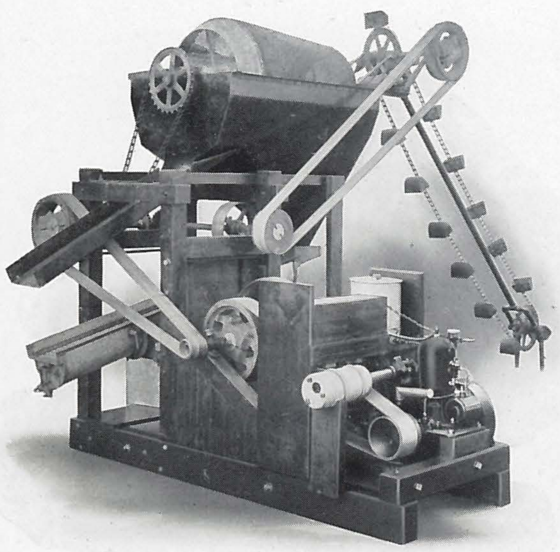
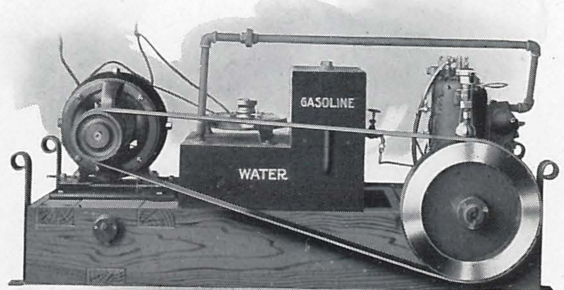


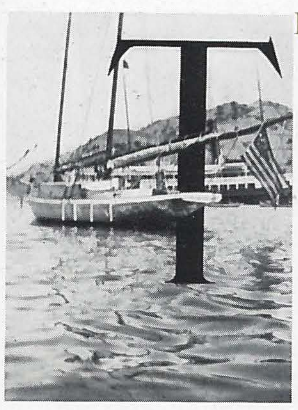
Illustration to the left shows a 4 HP. Ferro as applied for driving a concrete mixer.

On the right, a 4 HP. Ferro applied to a portable electric generator for lighting, vacuum cleaner systems, etc.



General Specifications of Ferro Marine Engines

OUTFIT B



THE engine and equipment of Outfit B comprise the engine completely fitted with its pump, pressure oil tank, sight-feed lubricating system, reversible contact timer with speed control lever and cut-out switch, automatic float-feed carburetor with throttle and compensating air valve, priming and relief cocks, priming can, spark plug, propeller shaft coupling and bolts, starting crank, ahead and reverse ball thrust bearings, water jacketed intake and exhaust header, Ferro expansion chamber, water scoop, can of cylinder oil, handy wrench, and complete fully illustrated book of instructions for installing in boat, operation, and care.

NOTE—An expansion chamber is furnished with all engines, except the FERRO SPECIAL. Where expansion chamber is not desired, a flange connection is supplied in place of the expansion chamber. The price in either case remains the same.

OUTFIT C

Engine and equipment of Outfit C include Outfit B complete and complete Ferro Ignition Equipment, comprising marine jump spark coil, one set dry batteries (6 cells encased in a non-conducting composition to prevent any possibility of short circuiting); one double throw switch; 10 feet tinned copper battery wire; 5 feet high grade jump-spark wire.

NOTE—With two cylinder motors we furnish 15 feet battery wire, 10 feet jump spark wire, and double marine spark coil.

With three cylinder motors we furnish 20 feet of battery wire, 15 feet jump spark wire, and triple marine spark coil.

OUTFIT D

Engine and equipment of Outfit D include Outfits B and C complete as above and a solid propeller equipment, comprising one suitable two or three-blade solid bronze propeller wheel; 5 feet (unless other length is specified) of bronze or steel propeller shaft; one bronze stuffing box with bronze lag screws.

IMPORTANT—In ordering this outfit state whether *propeller* adapted for *speed boats, or a propeller for fairly heavy* boats is desired. A two-blade propeller is furnished, unless a three-blade is ordered.

OUTFIT E

Engine and equipment of Outfit E include Oufits B and C complete as above and Ferro reversible propeller equipment, comprising a bronze reversible propeller with two or three blades, lever, quadrant, bronze sleeve and bronze stuffing boxes with bronze lag screws. Length of bronze or steel shaft, 5 feet, unless other length is specified.

OUTFIT F

Engine and equipment of Outfit F include Outfits B, C and D complete as above and reverse gear equipment, comprising the Ferro heavy duty reverse gear fitted to both coupling of propeller shaft and to the engine bed, together with the operating lever.

FERRO SPECIAL

OUTFIT B

Engine and equipment of Outfit B comprise the engine completely fitted with its pump, sight-feed oiler, reversible contact timer with speed control, automatic float feed Ferro carburetor with throttle and compensating air valve, priming and relief cock, spark plug, propeller shaft coupling, starting handle, ball thrust bearings, water scoop, can of cylinder oil, handy wrench, priming can and complete fully illustrated book of instructions, for installing in boat, operation, and care. (Does not include expansion chamber or muffler.)

OUTFIT C

Engine and equipment of Outfit C include outfit B complete and complete Ferro Special ignition equipment, comprising marine jump spark coil, one set dry batteries (6 cells encased in a non-conducting composition to prevent any possibility of short circuiting), one double throw switch, 8 feet tinned copper battery wire, 4 feet high grade jump spark wire.

NOTE—Outfits D, E and F of Ferro Special same as general specifications.

MAKE AND BREAK

OUTFIT B

Engine and equipment of Outfit B comprise the engine completely fitted with its pump, pressure oil tank, sight-feed lubricating system, Ferro Make and Break ignition equipment (consisting of ignitor plug, ignitor tripping device, timer device with lever), automatic float-feed carburetor with throttle and compensating air valve, priming and relief cock, priming can, spark plug, propeller shaft coupling, starting crank, ahead and reverse ball thrust bearings, water jacketed intake and exhaust header, Ferro expansion chamber, can of cylinder oil, water scoop, handy wrench and complete fully illustrated book of instructions for installing in boat, operation and care.

NOTE—An expansion chamber is furnished with all engines, except the FERRO SPECIAL. Where expansion chamber is not desired, a flange connection is supplied in place of the expansion chamber. The price in either case remains the same.

OUTFIT C

Engine and equipment of Outfit C include Outfit B complete as above and complete Ferro ignition equipment, comprising one marine Make and Break spark coil, one set dry batteries (6 cells encased in a non-conducting composition to prevent any possibility of short circuiting), one double throw switch, 15 feet tinned copper battery wire with single cylinder motor, and 20 feet with double cylinder motor.

Outfits D, E, F same as general specifications above.

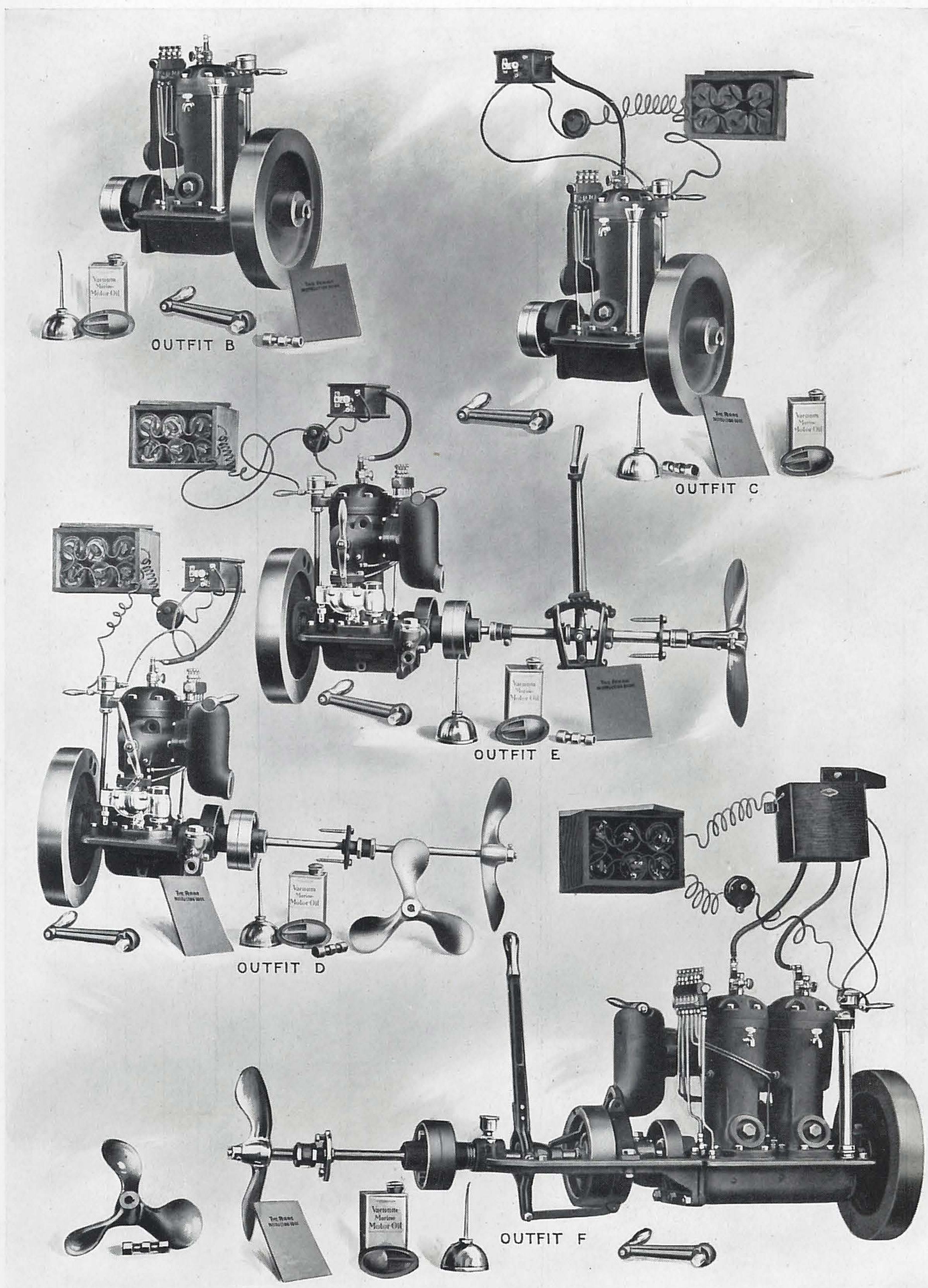
NOTES:

Air mufflers are not furnished with regular equipment; prices quoted on application.

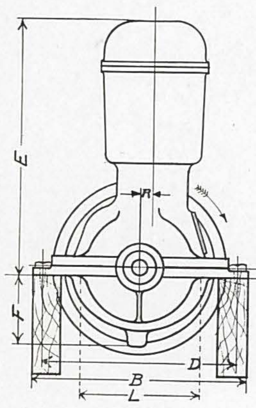
Any length of propeller shafting up to 5 feet furnished without extra charge; for prices see Repair Parts Price List.

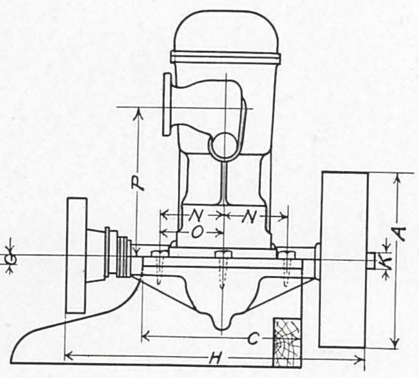
OPTIONAL EXTRAS

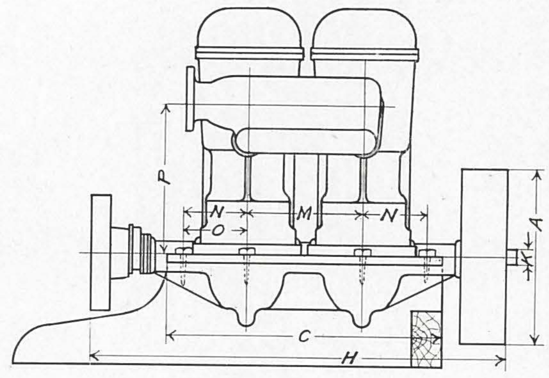
Besides the regular equipment, quotations will be made on application on the following extras: Rear starting device (both chain and lever); whistle and tank equipment complete with connections; dynamo and storage battery; magneto; wet cell batteries; complete kit of tools consisting of nine pieces.


OUTFIT B
OUTFIT C
OUTFIT E
OUTFIT D
OUTFIT F

Base Dimensions of Ferro Jump Spark and Make and Break Motors





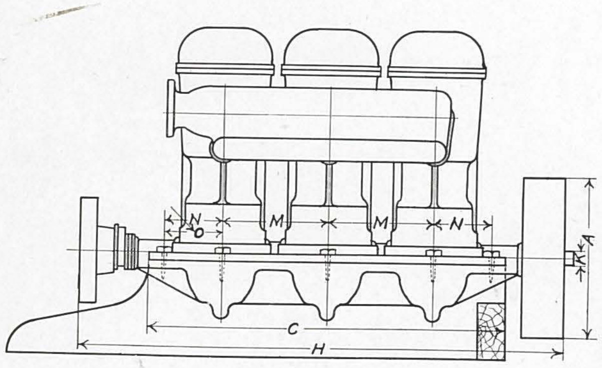


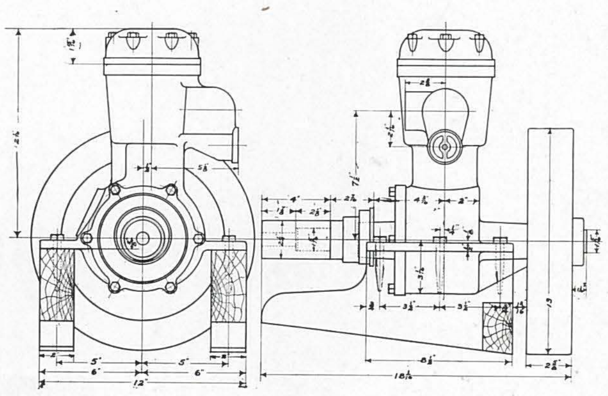
Single Cylinder Engines

Model	A	B	C	D	E	F	G	H	K	L	M	N	O	P
4 HP. O	15	13	9½	10¾	13¾	3$\frac{7}{16}$	$\frac{9}{16}$	18⅛	1⅜	8½	----	3½	3⅛	8$\frac{3}{16}$
5½.----F	16¼	14¼	10½	12	16½	4$\frac{1}{16}$	⅝	20⅝	1½	9	----	4⅛	3½	9$\frac{13}{16}$
7½ ----K	17½	16½	12	13½	19¼	4$\frac{11}{16}$	⅝	22	1¾	10	----	4¼	4¼	11$\frac{7}{16}$

Two-Cylinder Engines

Model	A	B	C	D	E	F	G	H	K	L	M	N	O	P
8 HP. P	15	13	15½	10¾	13¾	3$\frac{7}{16}$	$\frac{9}{16}$	24⅛	1⅜	8½	6	3½	3⅛	8$\frac{3}{16}$
11. ----G	16¼	14¼	18	12	16½	4$\frac{1}{16}$	⅝	28⅛	1½	9	7½	4⅛	3½	9$\frac{13}{16}$
15. ----L	17½	16½	20¼	13½	19¼	4$\frac{11}{16}$	⅝	30¼	1¾	10	8¼	4¼	4¼	11$\frac{7}{16}$





Three-Cylinder Engines

Model	A	B	C	D	E	F	G	H	K	L	M	N	O	P
12 HP. R	15	13	21½	10¾	13¾	3$\frac{7}{16}$	$\frac{9}{16}$	30⅛	1⅜	8½	6	3½	3⅛	8$\frac{3}{16}$
17.-----H	16¼	14¼	25½	12	16½	4$\frac{1}{16}$	⅝	35⅝	1½	9	7½	4⅛	3½	9$\frac{13}{16}$
25.-----M	17½	16½	28½	13½	19¼	4$\frac{11}{16}$	⅝	38½	1¾	10	8¼	4¼	4¼	11$\frac{7}{16}$

Ferro Special 3 H.P.

Model	A	B	C	D	E	F	G	H	K	N	P	R
3 HP----------T	13	12	8½	10	12$\frac{11}{16}$	3	⅝	16½	1$\frac{5}{16}$	3½	7½	½

General Dimensions

Horse Power: Make and Break	Horse Power: Jump Spark	Number of Cylinders	Bore and Stroke: Bore	Bore and Stroke: Stroke	Diameter of Fly Wheel	Diameter of Crank Shaft	Gasoline Opening	Exhaust Opening	Pump Connection Inlet	Overflow Connection Outlet	Length Propeller Shaft	Diameter Solid Propeller Shaft	Diameter Reverse Propeller Shaft	Diameter of Outside Sleeve	Diameter of Hole in Stern Post	Diameter of Reverse Wheel: 2 Blade	Diameter of Reverse Wheel: 3 blade
4	4	1	3¾	3½	15	1⅜	⅛	1¼	½	½	5 ft.	⅞	¾	1.03	1¼	16	..
5½	5½	1	4¼	4¼	16¼	1½	⅛	1½	¾	½	5 "	1	1	1.31	1⅝	18	16
7½	7½	1	5	5	17½	1¾	⅛	2	¾	½	5 "	1	1	1.31	1⅝	18	16
8	8	2	3¾	3½	15	1⅜	⅛	1¼	½	½	5 "	1	1	1.31	1⅝	18	16
11	11	2	4¼	4¼	16¼	1½	⅛	1½	¾	½	5 "	1⅛	1	1.31	1⅝	20	18
15	15	2	5	5	17½	1¾	⅛	2	¾	½	5 "	1¼	1¼	1.66	1⅞	22	20
..	12	3	3¾	3½	15	1⅜	⅛	1¼	½	½	5 "	1	1	1.31	1⅝	20	18
..	17	3	4¼	4¼	16¼	1½	⅛	1½	¾	½	5 "	1¼	1¼	1.66	1⅞	22	20
..	25	3	5	5	17½	1¾	⅛	2	¾	½	5 "	1⅜	1½	1.87	2¼	24	22

Ferro Special

Horse Power: Make and Break	Horse Power: Jump Spark	Number of Cylinders	Bore	Stroke	Diameter of Fly Wheel	Diameter of Crank Shaft	Gasoline Opening	Exhaust Opening	Pump Connection Inlet	Overflow Connection Outlet	Length Propeller Shaft	Diameter Solid Propeller Shaft	Diameter Reverse Propeller Shaft	Diameter of Outside Sleeve	Diameter of Hole in Stern Post	2 Blade	3 blade
..	3	1	3⅜	3¼	13	$1\frac{5}{16}$	⅛	1¼	⅜	¼	5 ft.	¾	¾	1.03	1¼	16	..

Weights

Horse Power		B		C				D				E				F			
		Engine		Equipment		Engine		Equipment		Engine		Equipment		Engine		Equipment		Engine	
Make and Break	Jump Spark	Net	Ship.	Net	Ship.	Net	Ship.	Net	Ship.	Net	Ship.	Net	Ship.	Net	Ship.	Net	Ship.	Net	Ship.
4	4	205	280	27	50	232	330	20	40	252	355	32	60	264	390	35	65	287	420
5½	5½	275	370	27	50	302	420	20	40	322	445	40	65	342	485	35	65	357	510
7½	7½	330	430	27	50	357	480	25	50	382	510	40	65	397	545	50	80	432	590
8	8	275	365	32	55	307	420	28	45	335	455	40	65	347	485	50	80	385	535
11	11	365	480	32	55	397	535	34	55	431	575	72	95	469	630	50	80	481	655
15	15	475	600	32	55	507	655	40	60	547	700	80	120	587	775	70	100	617	800
..	12	355	445	37	60	392	505	34	50	426	545	72	95	464	600	50	80	476	625
.	17	465	615	37	60	502	675	48	65	550	730	80	120	582	795	70	100	620	830
..	25	605	770	37	60	642	830	85	110	727	920	105	155	747	985	70	100	797	1020

Ferro Special

Make and Break	Jump Spark	B Engine Net	B Engine Ship.	C Equipment Net	C Equipment Ship.	C Engine Net	C Engine Ship.	D Equipment Net	D Equipment Ship.	D Engine Net	D Engine Ship.	E Equipment Net	E Equipment Ship.	E Engine Net	E Engine Ship.	F Equipment Net	F Equipment Ship.	F Engine Net	F Engine Ship.
..	3	135	200	25	45	160	245	20	40	180	270	32	60	192	305	35	65	215	335

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